SEASONAL VARIATIONS OF STREAMS AND GROUNDWATER QUALITY USING QUALITY INDEX

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ABSTRACT

The study examined the seasonal variation of streams and groundwater quality using quality index in Yakurr Local Government Area, Cross River State, Nigeria. Water samples were collected with plastic bottles well washed with chlorites nitrite acid followed by distilled water and rinsed thereafter, dried the plastic bottles and rinsed with the water to be collected. The samples were collected in six months, three months dry season and three months rainy seasons. Geographic positioning system (GPS) was used for constancy of the samples collection. The collected samples were stored in a cold box at 4^0C and taken for analysis of water quality parameters.

INTRODUCTION

Water supply sources are available to the people of Yakurr Local Government Area but quality has been questionable, especially for domestic purposes. Government has established boreholes across the landscape of the study area but the boreholes get dried up especially during the dry seasons due to reduced water table and poor drilling depth. Meanwhile public water supply by water board has been very erratic, unstable and unreliable. The people resort to other water sources (Ebin, 2016).

In Yakurr Local Government Area, majority of the people depend on streams, springs and groundwater for their daily water needs, due to inadequate supply of pipe-borne water by the government as well as their inability to meet the daily cost of buying boreholes. In some of these communities streams and boreholes constitute their main source of domestic water supply, sanitary and sewage systems are poor and where they exist they are poorly managed, thereby contaminating the available water source. Indeed, the quality of the sources of drinking water in the communities in the study area calls for concern as water from these sources is used by its inhabitants for drinking with little or no treatment.

Groundwater sources are continuously changing in nature and are influence by factors of urbanization geological processes, industrialization, irrigation activities occurring in the area and affecting aquifer minerals, rainfall patterns, infiltration rate, leaching, pollutants from the land surface, the contaminated water inturn affects plant growth and human health. The population is dependent on ground water resources for drinking purposes (Chartterjee, Tarafder & Powel, 2010, Nagarajan, Rajmohan, Mohendran & Senthamikuma, 2010, Ramanathan, 2008, Subba, 2009 and Yadar, Khan & Sharma, 2010). Water quality index is the greatest statistical method to show difficult water quality index data into a single number as an index which is in consonance with the works of Shankar and Latha (2008), Chaturvell and Bassin (2010), Sharma and Chipa (2013), Abua and Ajake (2014); Ebin (2016).

Materials and methods

Yakurr Local Government Area of Cross River State, Nigeria is located approximately between longitudes $8^0$11' and $8^0$20' E and latitudes $5^0$45' and $5^0$55'N of the equator. Yakurr Local Government Area is bounded in the North by Obubra, South by Biase, West by Abi and East by Akamkpa and Etung Local Government Areas. With a land mass of about 4,800 hectares that is 84km^2 (Enang, 2009).

Water samples were collected in diluted nitrit acid washed plastic bottles, followed by distilled water and rinsed, thereafter, dried containers were rinsed accordingly with the water to be collected (streams and boreholes) before the respective water samples were collected. Water samples were collected for six months, three

months dry season and three months rainy season. The months were January, February and March and July, August and September, 2014. The samples were collected once a week in both streams and boreholes, Geographic Positioning System (GPS) was used for constancy of the sample collection and the plastic bottles were properly labeled with dates according to sources of water, the collected samples were stored in a cold box at 4^0C and taken to the laboratory for physico-chemical and bacteriological parameters analyses. Insites measurements of streams parameters was measured in the field based on the parameters needed. Like pH, DO, TSS and TDS. and the parameters analyzed in the laboratory were total hardness (TH), chloride, potassium, sodium, calcium, magnesium, conductivity, total dissolve solid, sulphate, nitrate, bicarbonate, iron, copper, zinc, chromium, total coliform, calcium and magnesium.

Water quality index

Table 1

Water quality classification based on pollution index

Class	Pollution index	Status
Class 1		
BODS, Ca, conductivity, CL, DO, Fe, HCO_3, K, Na, NO_3, pH, PO_4, SO_4, TDS, total hardness	P1<1	No pollution
Class 2		
Mn, Temperature, turbidity	P1: 1-2	Slightly polluted
Class 3	P1: 2-3	Moderately polluted
Class 4	P1: 3-5	Strongly polluted
Class 5 Faecal coliform	P1: > 5	Seriously polluted

Water quality index

Water quality and it suitability for drinking purpose can be examined by determining its quality index (Caerio, Coasta, Rumos, Fernandes, Silverira, Colmbra & Painho, 2005). Prasad and Kumasi (2008) as cited in Ebin (2016).

Pollution index (PI) is given as:

$$P1 = \sqrt{\frac{\left(\frac{Ci}{Si}\right)max + \left(\frac{Ci}{Si}\right)^2 min}{2}}$$

Where

P1 = Pollution index

Ci = Mean concentration

Si = Nigeria Standard for drinking water quality (NS-DWQ, 2007)

TABLE 2

Comparison of measured water quality status with recommended standards

Water quality parameter	WHO permissible limits	FMEnv permissible limits	Surface water				Groundwater			
			Mean conc.	t-value*	df*	Sig.*	Mean conc.	t-value*	df*	Sig.*
$BOD_5(mgl^{-1})$	0	0	1.2785	52.737	287	< 0.001	.0737	8.129	311	< 0.001
Ca (ppm)	75	-	.0501	55850.00	287	< 0.001	.0455	-1247.00	311	< 0.001
Cl (mgl^{-1})	-	-	35.8781	-	-	-	72.1540	-	-	-
Conductivity (µS/cm)	-	-	1.0030E2	-	-	-	2.1390E2	-	-	-
DO (mgl^{-1})	8.0	7.5	4.9744	-81.041	287	< 0.001	4.6202	-122.909	311	< 0.001
Fe (ppm)	0.3	1.0	.0876	-77.129	287	< 0.001	.0575	-215.683	311	< 0.001
Faecal coliform (cfu/100ml)	0	0	1.2774E2	43.721	287	< 0.001	.5141	9.407	311	< 0.001
HCO_3 (mgl^{-1})	-	-	2.6047	-	-	-	5.5440	-	-	-
K (ppm)	50	-	.7458	1558.00	287	< 0.001	1.5883	-5262.00	311	< 0.001
Mn (ppm)	-	-	.0417	-	-	-	.0321	-	-	-
Na (ppm)	200	-	1.9093	-2453.0	287	< 0.001	4.2476	-12180.00	311	< 0.001
NO_3 (mgl^{-1})	1.0	1.0	5.4470	59.659	287	< 0.001	6.4440	104.438	311	< 0.001
pH (ppm)	6.5-8.5	6.5-8.5	6.0814	-11.226	287	< 0.001	5.4721	-30.932	311	< 0.001
PO_4 (mgl^{-1})	0	5	.0602	8.998	287	< 0.001	.1388	14.048	311	< 0.001
SO_4 (mgl^{-1})	400	500	5.0426	-1832.0	287	< 0.001	10.9296	-7046.00	311	< 0.001
TDS (mgl^{-1})	500	500	62.7614	-161.129	287	< 0.001	1.3503E2	-1191.00	311	< 0.001
Temperature (°C)	-	25-30	26.3969	-	-	-	25.7075	-	-	-
Total hardness (mgl^{-1})	500	200	31.2181	-374.11	287	< 0.001	18.4076	-1748.00	311	< 0.001
Turbidity(NTU)	500	1.0	8.5864	-1049.0	287	< 0.001	.1554	-1775.00	311	< 0.001

* Test based on WHO permissible limits

Source: Fieldwork, 2015

TABLE 4

Summary of degree of water pollution in Yakurr Local Government Area

Parameters	Minimum	Maximum	Mean	NSDWQ	pollution index
BOD_5 (mgl^{-1})	0.553	1.75	1.0376	0.00	0.976
Ca (ppm)	0.028	0.096	0.0492	200.00	0.0088
Conductivity ($\mu S/_{cm}$)	78.46	179.74	48.5153	1000.00	0.0981
Cl (mgl^{-1})	20.86	64.98	43.1334	250.00	0.1366
DO (mgl^{-1})	3.86	6.01	4.9035	10.00	0.3571
Fe (ppm)	0.044	0.183	0.070	0.30	0.3137
Feacal caliform (cfu/100m)	72.44	134.201	16.9649	10.00	7.625
HCO_3 (mgl^{-1})	1.164	6.077	3.1925	100.00	0.0309
K (ppm)	0.574	1.439	0.9144	150.00	0.0051
Mn (ppm)	0.018	0.1	0.0398	0.05	1.0161
Na (ppm)	1.556	3.418	2.377o	200.00	0.0094
NO_3 (mgl^{-1})	4.826	6.629	5.6464	50.00	0.0820
pH (ppm)	5.009	6.842	5.9595	7.50	0.5653
PO_4 (mgl^{-1})	0.0225	0.441	0.0759	0.50	0.4416
SO_4 (mgl^{-1})	4.324	9.918	6.2199	250.00	0.0203
TDS (mgl^{-1})	53.2845	108.063	38.2923	500.00	0.1205
Temperature (^oC)	23.915	28.39	26.259	25.00	1.11
Total hardness (mgl^{-1})	14.61	49.12	28.656	500.00	0.0512
Turbidity (NTU)	1.8875	14.14	6.9002	5.00	1.4265

Source: Fieldwork, 2015

Results and discussion

Variation in right quality with respect to World Health Organization (WHO) standards between water quality status with respect to WHO standards for domestic purposes. The students t-test was used in testing the hypothesis which allowed for comparison between the mean of the data set and a specific test value. The test value were the WHO permissible limit and the results of the water quality parameters tested in the cause of the study indicated those with negative signs on the t-values had concentrations below or within the WHO permissible limits while those with positive t-value had concentration above the Who permissible limit which is in agreement with the work of Garba, Gimba and Galaclima (2012).

The applicability of the pollution index on physico-chemical, heavy metal and bacteriological data revealed that the water samples in the study area had serious bacteriological contamination (with feacal coliform). Thus, a pollution index (PI) value of 7.63 implied that the water source were seriously polluted. This could have resulted from surface and ground water contact with human and animal faeces. It could also result from other means such as poor sanitary habit displayed by the host communities. The finding was in consonance with the works of Amadi (2012) and Abua and Ajake (2014) whose worked in Aba and Odukpani respectively. The WHO recommends a zero (0) per 100ml of feacal coliform for drinking water, meaning, water should have no concentration hence, the water should be treated to make it potable for human consumption. Many households in the area lacked standard toilets and soak aways, thus excreta were dumped on earth surface and stream channels. During rainfall, it infiltrated into the soil and flow into the water bodies. Furthermore, some hand-dog wells

were located very closely to pit-toilet/septic tanks, thus, the water got contaminated in the course of its movement.

Temperature and turbidity

Analysis of temperature and turbidity showed that they were slightly altered with P1 value of 1.11 and 1.02 respectively. This was as a result of the activities around those hydrospheric environments. Other parameters showed no signs of pollution as the (P.I) values were less than one (PI<1) (Table 1). Similarly, the concentration of heavy metals (Fe) fell within the permissible limits of Nigerian Standard for Drinking Water Quality (NSDWQ, 2007) except that of (Mn) with P1 value of 1.02 indicating that the water samples in the study area were slightly polluted (P<1). High iron content in the water may be due to chemical weathering of the bed-rock into lateritic soils and subsequent downward leaching into surface water and aquiferous zones in the area.

The concentrations of total hardness (TH) and total dissolved solid (TDS) were below the recommended maximum permissible limit of 150.00mg/1 and 500.00mg/1 respectively (NSDWQ, 2007). Calcium and magnesium irons in water may give rise to hardness and it does pose any changes in respect to quality (Amadi, 2012). Examining the spatial and seasonal variation in surface water quality in the study area, some parameters were tested for significance in four streams and 13 boreholes. There was a significant variation in water quality status BOD between the dry and rainy seasons and the interaction between the streams and seasons was also significant at the 0.05 level, the variation was as a result of variation in all the streams. The post hoc test results for BOD also showed a difference, similar to the work of Udosoro and Umoren (2014), Eni

and Efiong (2011). The test also revealed the existence of a significant variation in water quality status of NO^3 across the four streams in the study area.

In comparison of water quality parameters with WHO permissible limit, the data as presented in Table 2 showed a significant difference of both ground and surface water parameters indicating that those parameters with negative signs on the t-value have concentration below or within the Who permissible limit while those with positive t-values have concentration above WHO permissible limit which confirms the study of Udofia, Okorafor and Ntekim (2014) who compared water quality parameters with WHO permissible standard and it showed significant differences.

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