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DETERMINATION OF WATER QUALITY INDEX FOR DRINKING PURPOSE IN AKPABUYO, CROSS RIVER STATE, NIGERIA

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ABSTRACT

The present study was intended to calculate water quality index (WQI) of surface and groundwater in Akpabuyo for drinking and other purposes by using thirteen parameters: pH, conductivity, turbidity, TDS, TH, TDS, calcium, potassium, magnesium, sodium, chloride, nitrate and sulphate. Water quality index (WQI) in percentage (%) computed for the area ranged from 81.38 to 142.20 for groundwater and 131.46 to 231.98 for surface water which indicate that both the groundwater and surface water of the study area are unsuitable for human consumption and some industrial uses. (Word count-180)

KEYWORDS: WQI, pH, TDS, TH, TDS.

INTRODUCTION

Surface and groundwater are essential and vital components of our life support system. The deterioration in the surface and groundwater quality due to geogenic and anthropogenic activities has drawn great attention as the major sources of domestic and drinking water supply. Surface and groundwater samples from selected streams, river and boreholes were analysed for important physico-chemical parameters.

Water quality index (WQI) provides a single number that expresses overall water quality at a certain location and time, based on several water quality parameters (Jena et al., 2013). The objective of water quality index is to turn complex water quality data into information that is understandable and used by the public.

The water quality index based on some very important parameters provides a single indicator of water quality. In general, water quality indices incorporate data from multiple water quality parameters into a mathematical equation that rates the health of a water system with number. Physico-chemical properties of water in any aquatic ecosystem are largely governed by the existing meteorological conditions and are essential for determining the structural and functional status of natural water.

The present study was undertaken to define the quality of water samples with special reference to physicochemical properties to decide its Water Quality Index. The analyzed data were compared with standard values recommended by WHO (2004).

Study area

The present study was carried out in Akpabuyo Local Government Area (FIG.1), to evaluate water quality of surface and groundwater for drinking purpose. The study area, is located approximately between Latitude 4^0 45' and $5^0$05' North and Longitudes $8^0$20' and $8^0$40´ East. It covers an area of 1241 km^2. The climate of the area is typical of tropical humid region with a mean annual rainfall of 3500-4000 mm, a mean annual temperature of 26-27^{0}C and a mean relative humidity of 80-90%.

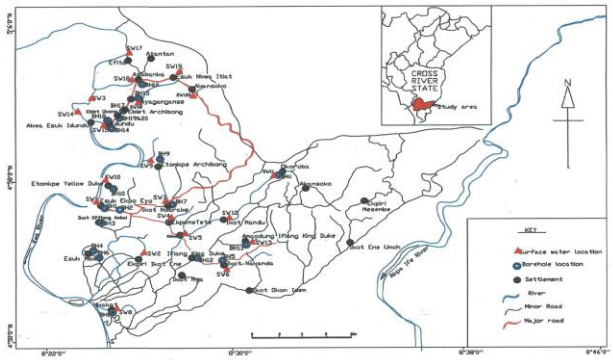

Fig.1: Map of the study area showing surface water and ground water sample locations.
Source: Adapted from Cross River State Surveyor General Map (2008).

MATERIALS AND METHODS

Surface and groundwater samples from 20 different locations respectively in the area were collected and analysed for 13 physicochemical parameters.

In this study the WQI was calculated by using the water quality recommended standards by WHO (2004). The weighted arithmetic index method was used for the calculation. Further quality rating or sub index (q_n) was calculated using the following expression:

$$q_n = 100x\ (V_n - V_i)$$

Where q_n = Quality rating for the nth water quality parameter
V_n = Estimated value of the nth parameter at a given sampling station.
V_i = Ideal value of nth parameter in pure water.

Unit weight (Wn) was calculated by a value inversely proportional to the recommended standard values (Sn) of the corresponding parameters:

$$W_n = K / Sn$$

Where, Wn = Unit weight for the nth parameter
Sn = Standard value for nth parameter
K = Constant of proportionality

In most cases Vi=0 except in certain parameters like pH and dissolved oxygen.
Calculating of quality rating for pH and DO (Vi≠0)
$q_{pH} = 100\ (VpH - 7.0) / (8.5-7.0)$ and
$q_{DO} = 100\ (V_{DO} - 14.6) / (Vs_n - 14.6)$

The overall Water Quality Index (WQI) was calculated by aggregating the quality rating with the unit weight linearly.

$$WQ\ I = \sum q_n\ Wn / \sum Wn.$$

RESULTS AND DISCUSSION

The result obtained from the analysis of water samples from Akpabuyo as was observed in September, 2014 are presented in Tables 2 and 3. Among all the physiochemical parameters selected for the Water Quality Index calculations, pH is an important parameter which determines the suitability of water for various purposes (Yogendra et al., 2008). The pH of water samples from the study area ranges between 4.10 and 6.0 for surface water and 3.84 to 6.64 for groundwater. Most of the samples were discovered to have pH values less than the WHO (2011) permissible limit of 6.5 to 8.5 for domestic use of the water. The results of the analysis indicate that waters are slightly acidic. Water with low pH can cause gastro intestinal disorders such as hyperacidity, ulcers, stomach pain and burning sensation (Jerome et. al., 2010). pH values below 6.5 cause corrosion of metals, resulting in the release of toxic metals such as lead, cadmium, copper etc. (Trivedy and Goel, 1986).

The turbidity in water is caused by particulate matters in suspension which results from land surface erosion. The surface and groundwater have mean turbidity values of 2.47NTU and 1.81NTU respectively . These values suggest that the surface water is higher in turbidity than the groundwater. Although the values are within WHO (2004) permissible standard of 5NTU for drinking water.

Dissolved oxygen (DO) ranged from 40 to 45mg/l and 25 to 35mg/l for surface and groundwater respectively. This is above the WHO (2004) recommended standard of 5mg/l for drinking water. Temperature, the types and concentrations of dissolved and suspended solid affect the amount of oxygen dissolved in river or stream, agitation of the water, and biotic activity.

Potassium ranges from 38 to 47mg/1 and 17 to 26mg/1 for surface and groundwater respectively. The WHO (2004) had stipulated a limit of 12mg/1 for potassium. Both surface and groundwater have high level of potassium with highest amount recorded in both water sources at Amadung Ifiang King Duke (SW 13 and BH 13). Because potassium is processed through the kidneys, the WHO has identified individuals with kidney disease or compromised renal functions as susceptible populations that may have significant adverse health effects due to increased potassium intake. In addition, the WHO also identifies infants, senior citizens and individuals suffering from heart disease, diabetes, hypertension, adrenal insufficiency, coronary heart disease, or who are taking medication that may elevate potassium levels, as groups susceptible to negative consequences of increased levels of potassium (Hoos, 2017.

A range of 0.01-0.11mg/1 and 0-0.02mg/1 for NO_3^- have been observed for surface and groundwater respectively. The maximum permissible level of Nitrate (NO_3^-) in domestic water supply according to WHO (2011) is 50mg/1. The concentrations of NO_3^- in surface and groundwater are within the WHO (2011) limits. Nitrates are a measure of the oxidized form of nitrogen and are essential macronutrient in aquatic environments. Nitrates can be harmful to humans, because our intestines can break nitrates down into nitrites which affect the ability of red blood cells to carry oxygen. Nitrites can also cause serious illness in fish (Srivastava et. al., 2013).

Other parameters such as conductivity, total dissolved solid (TDS), total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), chloride (Cl^-), and sulphate (SO_4^{2-}). are within WHO (2004) permissible standards.

Table 1: Water quality index (WQI) and status of water quality.

Water Quality Index Level	Water Quality Status
0-25	Excellent water quality
26-50	Good water quality
51-75	Poor water quality
76-100	Very poor water quality
>100	Unsuitable for drinking

Source: Chatterji and Raziuddin (2002)

Table 2: Calculation of water quality index for groundwater.

Parameter	WHO Standard	Unit Weight (Wn)	BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH8	BH9	BH10	BH11	BH12	BH13	BH14	BH15	BH16	BH17	BH18	BH19	BH20
pH	6.5-8.5	0.1176	4.30	2.28	4.30	4.34	4.09	4.07	2.30	4.95	6.64	4.60	4.35	4.59	4.10	3.84	4.00	4.09	4.10	4.93	3.89	4.24
Conductivity	250	0.0040	100	125	122	115	115	120	125	115	115	115	98	95	115	115	97	95	100	125	122	115
Turbidity	5	0.2000	1.50	2	2	1.80	1.50	1.50	1.60	1.80	2	2.10	1.90	1.80	1.80	1.60	2	2	1.50	2	2	1.80
TDS	1000	0.0010	87	75	90	69	78	92	79	88	98	92	80	95	97	67	89	84	87	75	90	69
Total hardness	75	0.0133	17	22	19	15	24	22	18	17	16	14	17	15	21	24	22	20	17	22	19	15
Dissolved Oxygen	5	0.2000	27	28	29	32	31	32	32	31	30	29	25	30	30	29	35	34	29	32	34	32
Calcium	75	0.0133	0.44	0.42	0.29	0.27	0.25	0.35	0.34	0.31	0.22	0.21	0.22	0.39	0.40	0.38	0.40	0.39	0.35	0.37	0.42	0.44
Potassium	12	0.0833	25	23	26	24	21	26	22	19	21	23	25	22	20	18	19	17	25	23	26	24
Magnesium	150	0.0067	0.10	0.20	0.20	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.10	0.20	0.20	0.01
Sodium	200	0.0050	17	19	12	13	11	16	15	10	18	12	14	17	15	15	12	11	17	19	12	13
Chloride	250	0.0040	17	18	14	16	17	14	15	17	18	18	14	15	16	17	19	19	17	18	14	16
Nitrate	50	0.0200	0.01	0.02	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.01	0.0	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.0	0.0
Sulphate	400	0.0025	14	19	19	15	22	26	16	25	19	22	16	21	15	27	26	19	14	19	19	15
		0.6707																				
Wn			0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707
q_n			638.34	794.93	688.50	684.50	673.77	730.36	809.78	597.80	497.80	636.54	457.77	620.24	658.35	648.97	707.73	669.24	672.39	659.87	766.26	694.06
WQI			105.73	133.57	116.04	121.51	116.81	125.16	142.20	106.15	86.55	109.89	81.38	110.28	114.13	110.89	130.98	124.69	114.28	115.02	136.47	123.15

Table 3: Calculation of water quality index for surface water.

Parameter	WHO Standard	Unit weight (Wn)	SW1	SW 2	SW 3	SW4	SW5	SW 6	SW 7	SW 8	SW 9	SW 10	SW 11	SW 12	SW 13	SW 14	SW 15	SW 16	SW 17	SW 18	SW 19	SW 20
pH	6.5-8.5	0.1176	6.00	4.10	4.95	4.63	4.53	4.62	4.45	4.45	5.00	4.40	4.32	4.40	4.32	5.84	4.31	4.56	5.63	4.54	5.23	5.50
Conductivity	250	0.0040	255	250	185	195	175	210	220	235	200	215	185	190	195	195	199	200	176	155	172	165
Turbidity	5	0.2000	2.70	2.50	2.50	2.50	2.40	2.40	2.40	2.50	2.40	2.30	2.30	2.50	2.40	2.60	2.50	2.50	2.50	2.40	2.50	2.50
TDS	1000	0.0010	187	172	169	185	135	142	172	168	125	134	176	155	167	165	159	155	172	169	185	135
Total hardness	75	0.0133	25	25	34	21	34	30	31	32	28	32	30	34	31	37	32	32	25	34	21	34
Dissolved Oxygen	5	0.2000	42	41	44	43	41	42	42	41	40	44	45	44	41	42	41	41	40	41	40	43
Calcium	75	0.0133	0.19	0.22	0.21	0.20	0.16	0.15	0.17	0.18	0.21	0.18	0.19	0.19	0.14	0.16	0.14	0.15	0.23	0.20	0.24	0.25
Potassium	12	0.0833	45	44	44	39	41	43	42	39	40	38	41	40	47	45	44	41	44	44	39	41
Magnesium	150	0.0067	0.41	0.33	0.43	0.19	0.18	0.21	0.22	0.21	0.30	0.50	0.41	0.25	0.44	0.39	0.35	0.27	0.33	0.43	0.19	0.18
Sodium	200	0.0050	24	21	18	20	24	23	19	22	24	25	24	20	21	22	23	21	21	18	20	24
Chloride	250	0.0040	21	22	24	21	26	25	25	22	21	24	25	25	23	22	24	25	22	24	21	26
Nitrate	50	0.0200	0.06	0.05	0.09	0.06	0.11	0.08	0.08	0.09	0.07	0.09	0.06	0.07	0.05	0.05	0.06	0.08	0.02	0.01	0.01	0.02
Sulphate	400	0.0025	31	28	30	29	25	28	30	32	39	32	29	33	34	27	28	29	28	30	29	25
		0.6707																				
Wn			0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707	0.6707
q_n			870.91	1062.44	1022.67	979.50	987.37	1017.62	1027.48	1001.83	939.85	1015.17	1044.50	1028.56	858.15	966.29	1071.02	995.79	920.38	994.16	948.98	941.37
WQ1			160.40	177.80	177.29	172.40	169.15	173.25	174.24	168.69	159.41	176.33	183.35	138.21	152.93	162.44	176.41	169.39	156.63	131.46	231.98	164.59

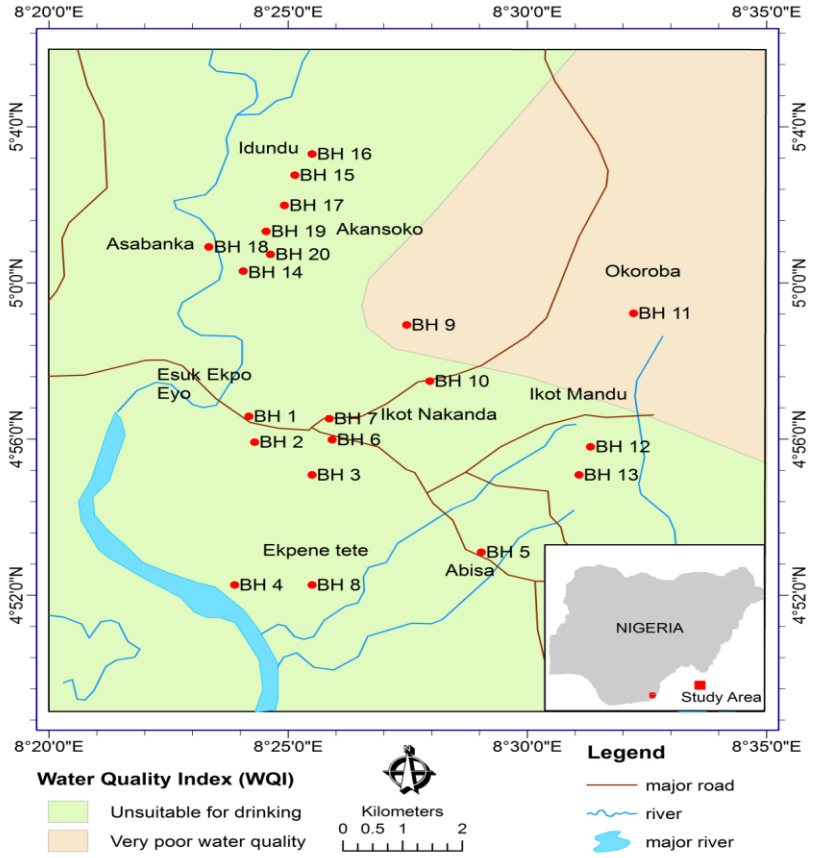

Fig. 2: GIS map showing water quality index in groundwater.

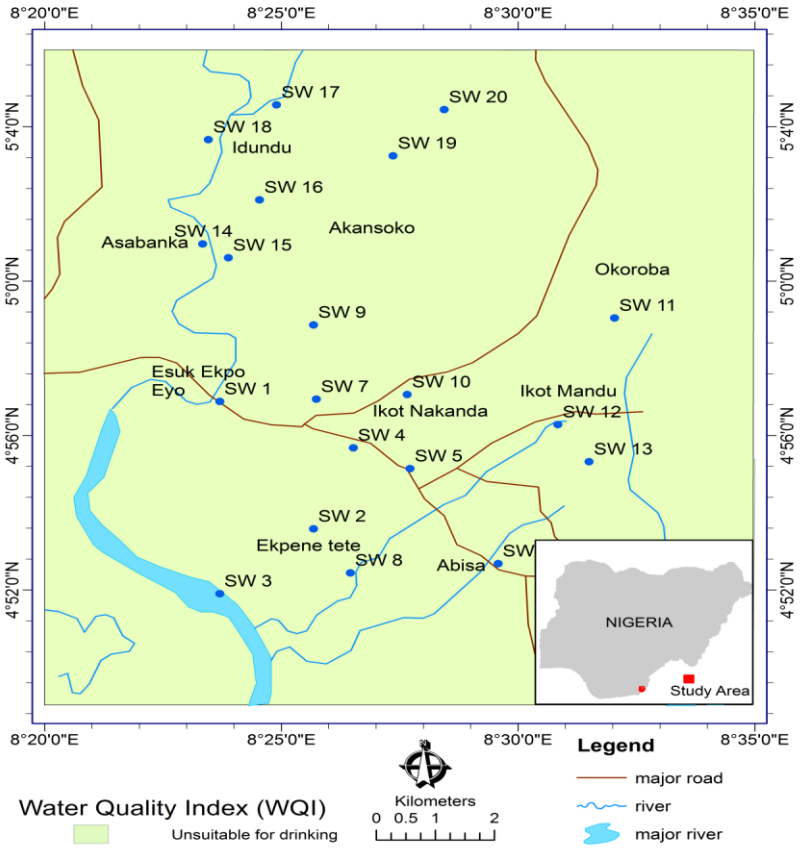

Fig. 3: GIS map showing water quality index in surface water.

CONCLUSION

The results indicate that some of the water quality parameters were beyond the permissible limits in the area.The Water Quality Index (WQI) is greater than 100 on the average for both ground and surface water, indicating that the water is unsuitable for drinking purpose (for human being, wild animals and cattle). For any surface and groundwater quality treatment programme, the point of consideration should be to bring the water quality index below 100 so as to achieve good quality of life.

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