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ASSESSMENT OF WATER QUALITY INDEX (WQI) AND SUITABILITY FOR CONSUMPTION OF ELELE-ALIMINI STREAM, PORT HARCOURT

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Abstract

This study was carried out to investigate the water quality index (WQI) and suitability for consumption of Elele-Alumini water, Port Harcourt between January –June 2018. Elele Alimini stream is a major source of domestic and industrial water for use. Water quality is centred on the respective aspects of the physico-chemical parameters by which the quality of water can be easily ascertained. Water samples collected from the three respective locations were analyzed following the standard method for the parameters such as temperature, pH, conductivity, and alkalinity, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Phosphate (PO_4), Sulphate (SO_3) and Nitrate (NO_3). SPSS software version 20 was used to carry out statistical analysis of the values of the water parameters measured. The values of these parameters were used to calculate the WQI of the stream. The WQI of the three locations were found to be 31.269, 29.050 and 26.429 respectively indicating that the water in the respective locations were of good quality (category II) and so suitable for drinking and for agriculture.

Key words: Assessment, water quality index, suitability, Elele- Alimini Stream, Port Harcourt

Introduction

Water is an essential resource especially for the existence of life which constantly cycles between the land and the air (Rumman *et al*, 2012). It is pertinent to note that water used for crop and animal production is also shared with the public and the aquatic and terrestrial ecosystem (Cooper *et al*, 1998). Due to the fact that fresh water is of great importance to mankind and directly linked to human welfare, it is therefore considered to be a top environmental issue and hence studied by wide range of specialists such as hydrologists, engineers, ecologists, geologists, and geomorphologists (Kumar and Dua, 2009). These surface water bodies (Rivers, lake, springs, creeks etc) which are important sources of water for anthropogenic activities are unfortunately under serious stress and so threatened due to the consequences of developmental activities. Globally, surface water characteristics are governed by the numerous anthropogenic (manmade) and natural processes (Javie *et al*, 1998, Ravichandran, 2003) such as weathering erosion, hydrological features, climate change, precipitation, industrial activities, agricultural land use, sewage discharges as well as human exploitation of aquatic resources (Mavie *et al*, 2005).

Water quality index (WQI) is a mathematical instrument used to transform large quantities of water data into a single number that expresses overall water quality at a certain location on several water variables which turns complex water quality data into information understandable and useable by the masses (Rumman *et al*, 2012). Water quality index is one of the most effective ways to communicate water quality where it is assessed on the basis of calculated water quality indices. Horton (1965) proposed the first WQI, a great deal of consideration has been given to the development of index methods. According to Miller *et al* (1986), WQI makes available, a mechanism for presenting a cumulatively derived numerical expression defining a certain level of water quality. WQI are classified broadly into two types which are physio-chemical (values are based on pbysico-chemical variables in water samples) and biological indices (values are based on biological information derived).

It is of importance to note that the significance of water bodies to man depends on its quality. Therefore in trying to improve the condition of these water resources, proper management is necessary with respect to indepth knowledge of these resources such as physiological, chemical and biological characteristics. Considering the above fact, it becomes important to assess the water quality index and suitability for consumption of Elele-Alumini water.

This study was carried out in Elele-Alumini Stream (New Calabar River), Emohua Local Government Area of Rivers State which lies between longitudes 5° 3'0" North and latitudes 6° 44'0" East (Figure 1). The River is known for numerous forms of anthropogenic activities such as irrigation, use of chemical (herbicides, pesticides, and insecticides), boating, refining oil and gas exploration, fishing, bathing etc. These aforementioned activities are capable of altering the physio-chemical characteristics of the water body and its indices since the activities may contribute to huge amount of municipal sewage and industrial effluents which can cause serious threat to aquatic life and food web.

The objective of this paper is to ascertain the water quality index of Elele-Alimini Stream and its suitability for human consumption.

Materials and Methods

Water samples were collected from the water on monthly basis and analyzed for eight (8) physico- chemical parameters following the standard methods of APHA (1995). The parameters studied which include temperature, PH, conductively and dissolved organic (DO) were measured in-site while others like Total alkalinity, biological oxygen chemical (BOD) salinity and the water nutrients (phosphate, nitrate and sulphate) were analyzed in the laboratory following the standard procedures of APHA (1995).

The calculation of water quality index (WQI) made use of the eight (8) chosen important parameters aforementioned. The standards of drinking water quality recommended by the World Health Organisation (WHO), Bureau of Indian Standards (BIS) and Indian Council for Medical

Research (ICMR) were followed in the calculation of Water Quality Index (WQI). The weighted arithmetic Index Method (Brown *et al*.1970) was used for the calculation of WQI and quality rating or sub index (qn) was calculated using the expression $qn = 100 \, {(V_n - V_{io})}/{(S_n - V_{io})}$

Where

qn = Quality rating for the nth water quality parameters

Vn = Estimated value of the nth water quality parameters of collected sample,

Sn = Standard permissible value of the nth water quality parameters

Vio = Ideal value of the nth water quality parameter in pure water (i.e O for all other parameters except the parameters pH and Dissolved Oxygen (7.0 and 14.6mg/1 respectively).

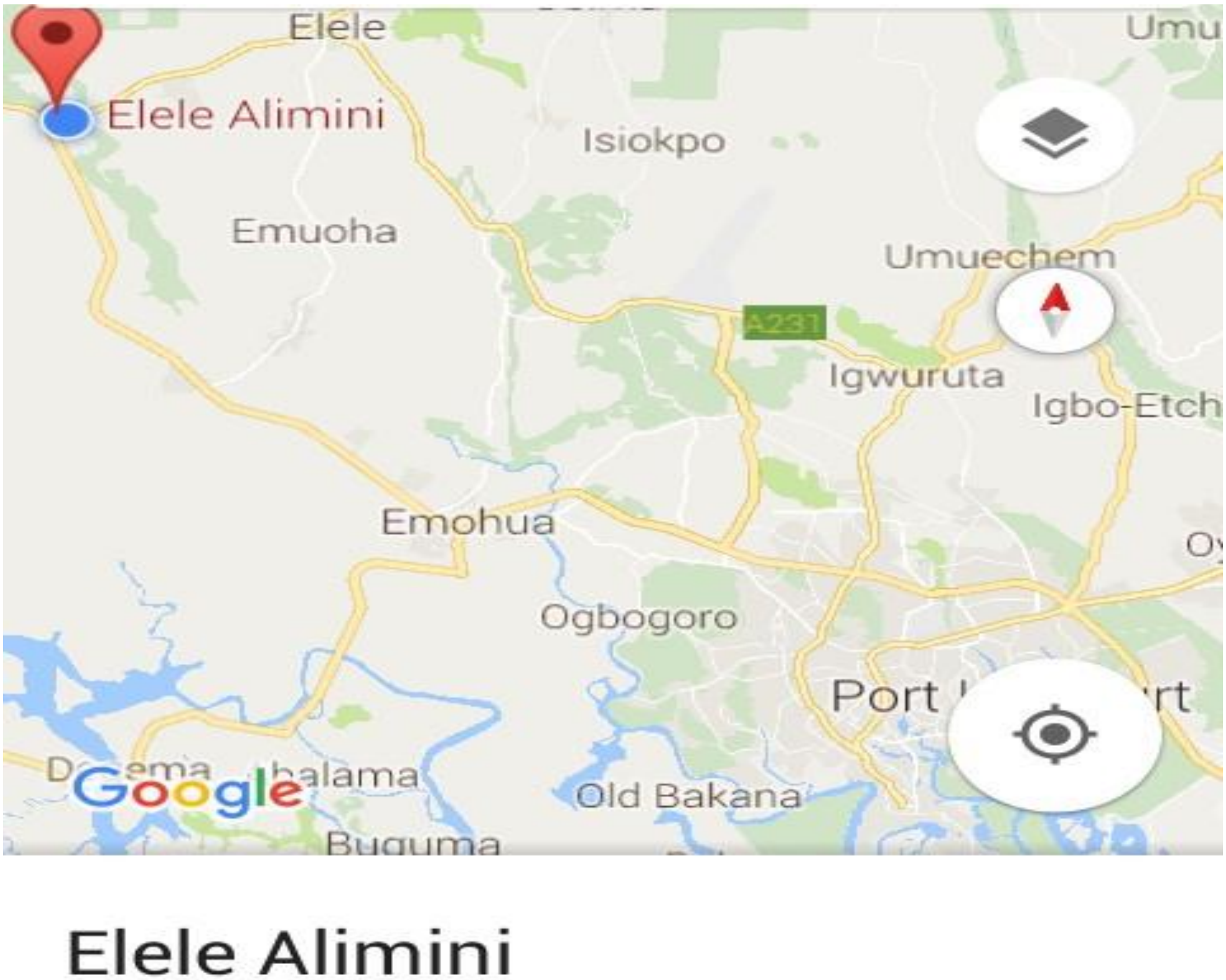

Figure 1: Map of the Study area showing sampling stations

Unit weight (Wu) was calculated by a value inversely proportional to the recommended standard value Sn of the corresponding parameter.

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Therefore:

Wn = K/Sn

Where

Wn = Unit weight for the nth parameters

Sn = Standard value for nth parameters

K = Constant for proportionality

The overall WQI was therefore calculated by aggregating the quality rating with the unit weight linearly as follows:

$$WQI = \sum qnWn \Big/ \sum Wn$$

Where

qn = Quality rating for nth water quality parameter

wn = Unit weight for nth water quality parameter

Results

The results are as presented on the tables as below:

Table 3 shows the spatial variations of the various physicochemical parameters studied in the study area. pH fluctuates between 5.89$\pm$0.29 and 6.06$\pm$0.30. The pH values for station 2(5.90$\pm$0.00) and 3(5.87$\pm$0.29) were below the standard value while station 1(6.06$\pm$0.30) is within the standard (Table 2).

The spatial mean values of electrical conductivity, alkalinity, Biological Oxygen Demand (BOD), phosphate, nitrate and sulphate were all ranged below the standard values while dissolved oxygen (Do) was above the standard value of 5.0mg/l (Table 3 and 2).

Table 4 – 6 showed the calculated values of water quality indices for the various stations which were 3.267, 29.050 and 26.429 for stations 1 – 3 respectively.

Table 1:Water Quality Index and Status

Class	Water Quality Index Level	Water Quality Status
1	0-25	Excellent water Quality
2	26-50	Good water Quality
3	51-75	Poor water Quality
4	76-100	Very poor water quality
5	>100	Unsuitable water quality

GSJ: Volume 7, Issue 2, February 2019
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Table 2: Drinking water standards recommending Agency and Unit Weight (All values are in mg/l except pH and Electrical conductivity.

S/N	Parameters	Standards	Recommended Agency	Unit Weight
1	pH	6.5-8.5	ICMR/BIS	0.0302
2	Electrical Conductivity	300	ICMR	0.0009
3	Alkalinity	120	ICMR	0.0021
4	Dissolved Oxygen(DO)	5.0	ICMR/BIS	0.0514
5	Biological Oxygen Demand	5.0	ICMR/BIS	0.0514
6	Phosphate	0.30	IS	0.8566
7	Nitratre	45	ICMR/BIS	0.0057
8	Sulphate	150	ICMR/BIS	0.0017

Table 3:Spatial Values of the Physico-chemical Parameters of the Study Area

S/N	Parameters	Station 1	Station 2	Station 3
1	pH	6.06±0.30	5.90±0.00	5.87±0.29
2	Electrical Conductivity	130.16±26.36	123.70±14.95	127.91±18.49
3	Alkalinity	46.93±0.97	51.93±2.66	51.08±5.97
4	Dissolved Oxygen	6.50±0.62	6.56±0.05	6.60±0.46
5	Biological Oxygen Demand(BOD)	2.01±0.07	2.35±0.25	2.10±0.31
6	Phosphate	0.08±0.00	0.07±0.02	0.04±0.01
7	Nitrate	0.50±0.10	0.52±0.07	0.04±0.17
8	Sulphate	1.83±0.28	1.47±0.23	1.57±0.27
	Water Quality Index (WQI)	**31.267**	**29.050**	**26.429**

Table 4: Calculation of Water Quality Index (WQI) for Statio 1

S/N	Parameters	Observed Value	Sn	Wn	qn	Wnqn
1	pH	6.06	6.5-8.5	0.0302	62.667	1.895
2	Conductivity	130.16	300	0.0009	43.387	0.039
3	Alkalinity	46.93	120	0.0021	39.108	0.082
4	DO	6.50	5.0	0.0514	84.375	4.337
5	BOD	2.01	5.0	0.0514	40.200	2.066
6	Phosphate	0.08	0.3	0.8566	26.667	22.843
7	Nitrate	0.50	45	0.0057	1.111	0.006
8	Sulphate	1.83	150	0.0017	1.220	0.002
	Summation (Ƹ)			**1.0001**	**538.735**	**31.270**

Water Quality Index (WQI) = $\sum qnWn / \sum Wn$ **= 31.267**

GSJ: Volume 7, Issue 2, February 2019
ISSN 2320-9186

Table 5: Calculation of Water Quality Index (WQI) for Statio 2

S/N	Parameters	Observed Value	Sn	Wn	qn	Wnqn
1	pH	5.90	6.5-8.5	0.0302	73.333	2.215
2	Conductivity	123.70	300	0.0009	41.233	0.037
3	Alkalinity	51.93	120	0.0021	43.275	0.091
4	DO	6.56	5.0	0.0514	83.750	4.305
5	BOD	2.35	5.0	0.0514	47.000	2.416
6	Phosphate	0.07	0.3	0.8566	23.333	19.987
7	Nitrate	0.52	45	0.0057	1.156	0.007
8	Sulphate	1.47	150	0.0017	0.980	0.002
	Summation (Ʃ)			**1.0001**	**314.060**	**29.060**

Water Quality Index (WQI) = $\sum qnWn / \sum Wn$ **= 29.050**

Table 6: Calculation of Water Quality Index (WQI) for Statio 3

S/N	Parameters	Observed Value	Sn	Wn	qn	Wnqn
1	pH	5.63	6.5-8.5	0.0302	91.333	2.758
2	Conductivity	129.86	300	0.0009	43.287	0.039
3	Alkalinity	54.40	120	0.0021	45.333	0.095
4	DO	6.73	5.0	0.0514	81.979	4.214
5	BOD	1.93	5.0	0.0514	38.600	1.984
6	Phosphate	0.06	0.3	0.8566	20.000	17.334
7	Nitrate	0.20	45	0.0057	0.444	0.003
8	Sulphate	1.43	150	0.0017	0.953	0.002
	Summation (Ʃ)			**1.0001**	**321.929**	**26.429**

Water Quality Index (WQI) = $\sum qnWn / \sum Wn$ =26.429

Discussion

According to Rumman *et al* (2012) water quality index is a mathematical instrument used to transform large quantities of water data into a single number that expresses overall water quality at a certain location on several water quality variables turning complex water quality data into information understandable and useable by the masses.

The slight deviation of the various water variables studied above and below the permissible limits in this study is a clear indication that the water body could be under slight strees and threat attributed to natural and anthropogenic activities.

The various water quality indices (31.269, 29.050 and 26.429) obtained from the stations of this water body in this study indicates that the water is of good quality (Chatterji and Raziuddin, 2002) since it falls within the range of 26 – 50. The results also showed that the order of quality of the water is station 3 > 2 > 1 meaning that station 3 is the best of all the stations in terms of quality. The results therefore showed that the water is not polluted but might contain some contaminates whose concentration is not enough to prevent humans from consuming the water.

The water quality rating with respect to all the parameters except dissolved oxygen and pH clearly showed that the water is not eutrophic and therefore suitable for human consumption.
pH in this study which ranged between 5.87±0.29 and 6.06±0.30 is acidic and therefore contrary to the alkaline condition reported by Ambasht (1971), Warnalatha and Narasingarao (1993), Shardendu and Ambasht (1988) and Petre (1975) in different water bodies. The low value of pH below the permissible limit (6.5 – 8.5) in this study in the entire stations could be attributed to environmental factors in the area.

Electrical conductivity in this study ranged between 123.70±14.95 and 130.16±26.36 µs/cm which is equivalent to the permissible limit (130µs/cm).
Alkalinity ranged between 46.93±0.97 and 51.93±2.66µs/cm in this study which is far below the permissible limit (120mg/l) and could be attributed to the carbonate, hydroxide content and contributions from borates, phosphate, silicates and other bases in the area.
DO value in this study ranged between 6.50±0.62mg/l and 6.60±0.46mg/l which is slightly above the permissible limit (5mg/l). The DO concentration of a water body regulates distribution of biota in the area. DO value in this study is in disconformity with the observations of Swarnalatha and Narasingarao (1993) and Venkafeswarlu (1993).

BOD ranged between 2.01±0.07mg/l and 2.35±0.25mg/l is far below the permissible limit (5.0mg/l). This could be attributed to little level of organic load in the water. This range is in discomformity with the 28mg/l to 33mg/l reported by Chatterjee (1992).

The values of the water nutrients (PO_4, NO_3 and SO_4) were all far below the permissible limit. The values of the water nutrients (PO_4, NO_3 and SO_4) show that the water does not have characteristics of eutrophication. This is confirmed by the assertion by Harbel (2009) that water nutrients such as phosphate, nitrate and sulphate control eutrophication and algal growth in the aquatic ecosystem.

Conclusion

The water quality index as calculated from the physicochemical variables showed that the water is neither eutrophic nor polluted and so suitable for human consumption.

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