Water Quality Index and Status of Minichinda Stream, Port Harcourt, Nigeria

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Abstract
The water quality index and status of Minichinda stream Port Harcourt was studied between July 2006 and June 2007. Minichinda stream is one major stream that receives wastes from anthropogenic activities in the area. Water samples were collected from four strategic locations and analyzed following the standard method for the parameters which include temperature, pH, conductivity, alkalinity, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Phosphate (PO_4), Sulphate (SO_3) and Nitrate (NO_3). The values obtained from this study were subjected to statistical analysis using SPSS software. The calculation of water quality index (WQI) made use of the mean values of the nine (9) parameter chosen using the standards recommended by the World Health Organization (WHO), Bureau of Indian Standards (BIU) and Indian Council for Medical Research (ICMR) for drinking water quality. The water quality indexes for the water body spatially were 29.732, 37.944, 79.342 and 28.127 for stations 1-4 respectively. The values of the WQI showed that sampling stations 1, 2 and 4 were free of impurities unlike that of station 3 which is considered to be of very poor quality. It was concluded that WQI is used as a tool for comparing the quality of water of different sources and locations. It was also recommended that water from the sampling station 3 should be adequately monitored and possibly treated before use to avoid health related issues.

Keywords: *water quality index, anthropogenic activities, Minichinda stream, Port Harcourt*

Introduction

It is glaring that the rate of deterioration of fresh water which is the most concern for mankind is on the increase due to global increase in anthropogenic activities. Several numbers of surface and ground water bodies which are the sources of water for human activities are under environmental stress and threat which are direct consequences of anthropogenic activities (Manjunatha and Lokeshappa, 2015). So many domestic and industrial activities such as food manufacturing industries, artisanal food processing and oil drilling activities going on around the surface and ground waters end up discharging their waster (pollutants) into the water bodies. This act results in the alteration of the physicochemical characteristics of the water. In other to control or regulate the negative impact of these human activities on water bodies and their surrounding safe, environmental management plan has to be put in place. This therefore makes environmental protection as essential tool along economic gains. The limits of those physicochemical parameters harmful to human health have been established at national and international level (WHO, EPA, MECC) by several laws, regulations and normative.

Water quality index provides a single number that expresses overall water quality at a certain location and time based on several water quality parameters. Basically, a water quality index attempts to provide a mechanism for representing a cumulatively derived, numerical expression defining a certain level of water quality (Miller *et al*., 1986). Worldwide, it is not a single index that can describe overall water quality for any water body. Therefore, global index of water quality is needed to assess changes in water quality overtime and space and also to evaluate successes and failures of international treaties designed to protect aquatic resources. Several number of countries have begun the processes of developing composite indices of water quality to describe the state of their domestic waters, including the United States of America (Cude, 2001), Taiwan (Liou *et al.*, 2004), Argentina (Pesce and Wunderlin, 2000), Australia (ICS, 2005), Canada (Khan, *et al.*, 2003, Lumb *et al.*, 2006, (MME 2001) and New Zealand (Smith, 1989, 1990, Nagels *et al*., 2001).

Minichinda stream plays vital roles in the lives of the inhabitant since it serves as their source of livelihood which is fishing. Fishing, bathing, car washing, refuse disposal, industrial wastes disposal and other anthropogenic activities too numerous to mention are constantly going on around and within the area (Davies, *et al.*, 2006). It therefore became necessary to carry out this research to determine the water quality index and status of this stream.

Materials and Methods

Study Area

Minichinda stream lies between longitude $6^{0}50'$E - $7^{0}50'$E and latitude $5^{0}05'$N – $5^{0}06'$N. The stream is located at Rumukwurushi in Obio/Akpor Local Government Area of Rivers State. It has dense and thick tropical rainforest vegetation characterized by high atmospheric temperature ($27^{0}.5^{0}$C) and high relative humidity fluctuating between 65 – 90%. It also has average rainfall of about 2500mm (Gobo, 1988).

Sampling Stations

The four sampling stations chosen were 500 m apart along the main stream course which include the following (fig 1)

Station 1: Pipeline (upstream)
Section 2: NNPC Housing Estate (point source of industrial & domestic disc charges)
Station 3: Mgbuogaza
Station 4: Rumuochiorlu (downstream)

Samples collection and analysis

Surface water samples were collected monthly between July 2006 and June 2007 and analyzed according to standard method (APHA, 1998) for a physicochemical parameters, pH, conductivity, alkalinity, chloride, dissolved oxygen, biochemical oxygen demand phosphate, nitrate and sulphate.

Data obtained were subjected to analysis of variance (ANOVA) and Duncan Multiple Range Test (DMRT) using SAS (2003) and Microsoft excel (2003) packages.
The calculation of water quality index (WQI) made use of the nine (9) parameter chosen. The standards recommended by the World Health Organization (WHO), Bureau of Indian Standards (BIU) and Indian Council for Medical Research (ICMR) for drinking water quality were followed in the calculation of water quality index. The weighted arithmetic index method (Brown *et al*., 1970) was used for the calculation of WQI of the water body while quality rating or sub index (qn) was calculated from the expression:

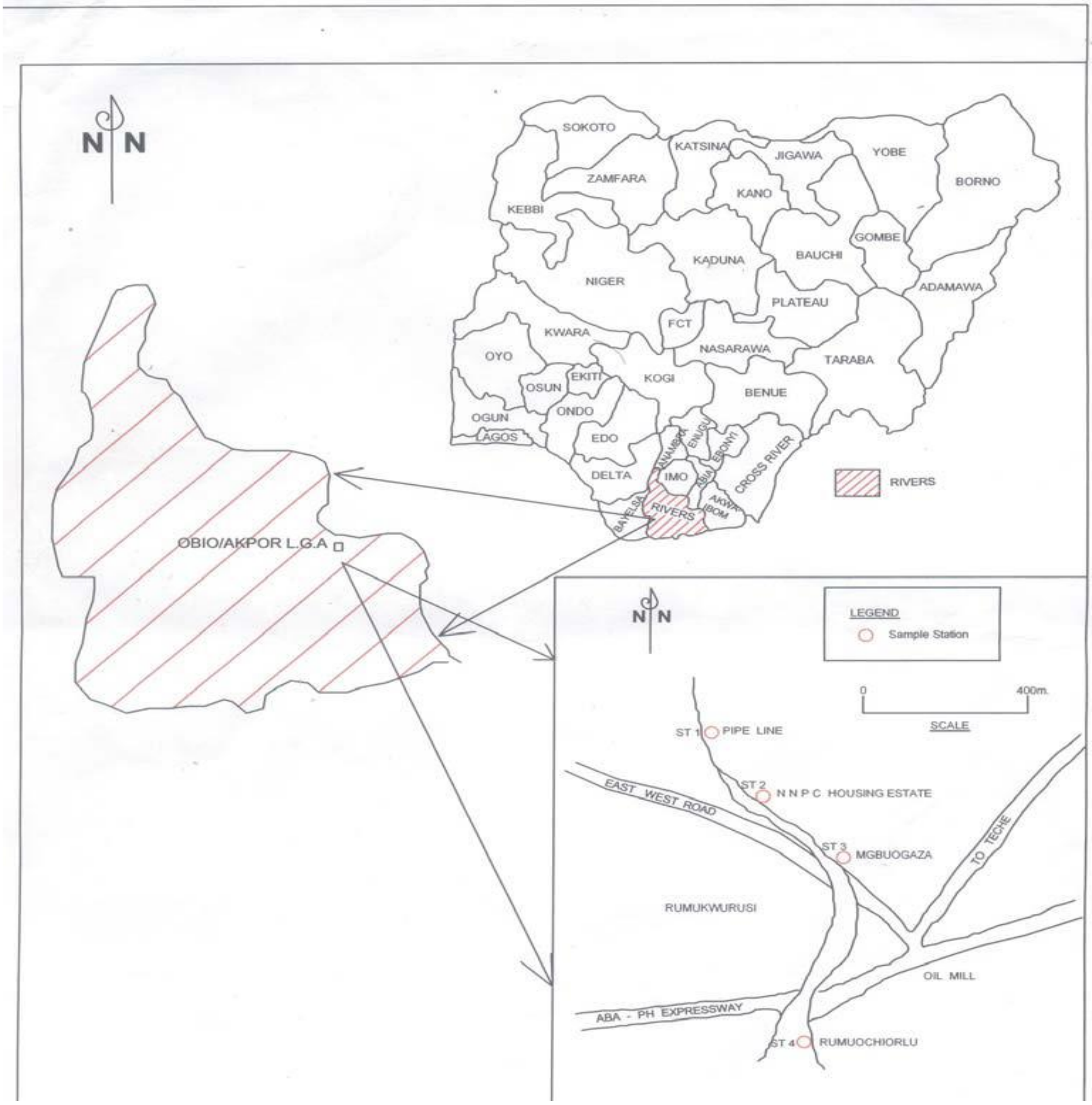

Figure1: Map of the study area showing the sampling stations

$$qn = 100 \frac{(Vn - Vio)}{(Sn - Vio)}$$

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 parameters in pure water (i.e O for all other parameters except pH and Do which are 7.0 and 14.6mg/l respectively).

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

$$Wn = \frac{K}{Sn}$$

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

The overall WQ1 was therefore calculated by aggregating the quality rating with the unit weight linearly as follows:

$$WQI = \sum qnwn / \sum wn$$

Results

The results are as shown on table 3 – 7 below.

The spatial values of the physicochemical parameters of the study area are as shown on table 3. pH values showed acidic range (5.97±0.09–6.32±0.17) with little variation spatially while electrical conductivity values showed wide margin (53.08±4.60 – 289.01±40.83us/cm) with high values in stations 3 and 4. Alkalinity values ranged between 30.08 $\pm$ 0.90 and 95.58 $\pm$ 24.26mg/l with highest value in Station 3 which are all below the standard value (120mg/l) (Tables 2 and 3). Chloride ranged between 3.85 $\pm$ 0.50 and 5.77 $\pm$ 0.65 which are all far below standard value (250mg/l). Dissolved oxygen values ranged between 0.51 $\pm$ 0.36 and 7.45 $\pm$ 0.26mg/l with the highest and minimum in station 1 and 3 respectively. Station 1, 2 and 4 values showed little variation but differs greatly from station 3 which was far lower than the standard value (5.0mg/l). BOD values ranged between 1.52 $\pm$ 0.20 and 2.48 $\pm$ 0.24 with little variation. BOD value was highest in station 3. The values of the water nutrients ($D0_4$, $N0_3$ and $S0_4$) were all far below the standard values (Table 2 and 3). The water quality indices for the water body spatially were respectively 29.732, 37.944, 79.342 and 28.127 for stations 1-4 with station 4 having the highest index value indicating that the water is very poor (Tables 1and 3-7).

Table 1: Water Quality Index and Status

Class	Water Quality Index	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

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	Chloride	250	ICMR/BIS	
5	Dissolved Oxygen(DO)	5.0	ICMR/BIS	0.0514
6	Biological Oxygen Demand	5.0	ICMR/BIS	0.0514
7	Phosphate	0.30	BIS/WHO	0.8566
8	Nitrate	45	ICMR/BIS	0.0057
9	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	Station 4
1	pH	5.97±0.09	6.24±0.10	6.32±0.17	6.01±0.18
2	Electrical Conductivity	60.00±5.40	53.08±4.60	289.01±40.83	167.75±21.30
3	Alkalinity	33.00±0.65	30.08±0.90	95.58±24.26	58.08±23.21
4	Chloride	4.62±0.42	3.85±0.50	5.77±0.65	5.77±0.65
5	Dissolved Oxygen	7.45±0.26	7.23±0.24	0.51±0.36	7.30±0.30
6	Biological Oxygen Demand(BOD)	1.52±0.20	1.66±0.21	2.48±0.24	1.94±0.61
7	Phosphate	0.06±0.00	0.06±0.00	0.16±0.04	0.06±0.00
8	Nitrate	0.43±0.11	0.47±0.09	0.54±0.08	0.70±0.10
9	Sulphate	1.56±0.29	1.84±0.22	2.59±0.77	2.08±0.51
	Water Quality Index (WQI)	**29.732**	**37.944**	**79.342**	**28.127**

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

S/N	Parameters	Observed Value	Sn	Wn	qn	Wnqn
1	pH	5.97	6.5-8.5	0.0302	68.667	1.895
2	Conductivity	60.00	300	0.0009	20.000	0.039
3	Alkalinity	33.00	120	0.0021	27.500	0.082
4	Chloride	4.62	250	0.00026	1.848	0.00048
5	DO	7.45	5.0	0.0514	74.379	4.337
6	BOD	1.52	5.0	0.0514	30.400	2.066
7	Phosphate	0.06	0.3	0.8566	20.000	22.843
8	Nitrate	0.43	45	0.0066	1.040	0.006
9	Sulphate	1.56	150	0.0057	0.956	0.002
	Summation (Ƹ)			**1.0129**		**30.115**

Water Quality Index (WQI) $= \sum qnWn / \sum Wn$ **= 29.732**

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

S/N	Parameters	Observed Value	Sn	Wn	qn	Wnqn
1	pH	6.24	6.5-8.5	0.0302	50.667	2.215
2	Conductivity	53.08	300	0.0009	17.693	0.037
3	Alkalinity	30.08	120	0.0021	25.067	0.091
4	Chloride	3.85	250	0.00026	0.0154	0.000004
5	DO	3.85	5.0	0.0514	76.771	4.305
6	BOD	7.23	5.0	0.0514	33.200	2.416
7	Phosphate	1.66	0.3	0.8566	20.000	19.987
8	Nitrate	0.06	45	0.0057	1.2267	0.007
9	Sulphate	0.47	150	0.0066	1.0444	0.002
	Summation (Ƹ)			**1.0129**		**38.433**

Water Quality Index (WQI) $= \sum qnWn / \sum Wn$ **= 37.944**

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

S/N	Parameters	Observed Value	Sn	Wn	qn	Wnqn
1	pH	6.32	6.5-8.5	0.0302	91.333	2.758
2	Conductivity	289.01	300	0.0009	43.287	0.039
3	Alkalinity	95.58	120	0.0021	45.333	0.095
4	Chloride	5.77	250	0.00026	2.3080	0.0015
5	DO	0.51	5.0	0.0514	146.7708	7.5440
6	BOD	2.48	5.0	0.0514	49.600	25.4944
7	Phosphate	0.16	0.3	0.8566	53.333	45.6853
8	Nitrate	0.54	45	0.0057	0.444	0.003
9	Sulphate	2.59	150	0.0066	1.7267	0.0114
	Summation (Ƹ)			**1.0001**	**321.929**	**80.365**

Water Quality Index (WQI) $= \sum qnWn / \sum Wn$ **=79.342**

Table 7: Calculation of Water Quality Index (WQI) for Station 4

S/N	Parameters	Observed Value	Sn	Wn	qn	Wnqn
1	pH	6.01	6.5-8.5	0.0302	66.000	1.895
2	Conductivity	167.75	300	0.0009	56.583	0.039
3	Alkalinity	58.08	120	0.0021	48.400	0.082
4	Chloride	5.77	250	0.00026	2.308	0.00015
5	DO	7.30	5.0	0.0514	2.308	4.337
6	BOD	1.94	5.0	0.0514	76.	2.066
7	Phosphate	0.06	0.3	0.8566	26.667	22.843
8	Nitrate	0.70	45	0.0057	01.556	0.00887
9	Sulphate	2.08	150	0.0066	1.387	0.0092
	Summation (Ƹ)			**1.0129**		**28.490**

Water Quality Index (WQI) $= \sum qnWn / \sum Wn$ **= 28.127**

Discussion

The result showed that there are variations between the physicochemical variables studied indicating that the water body is under slight stress and threat which could be attributed to little load of organic and in organic materials in the water body resulting from anthropogenic activities (CCME, 2001, CCME, 2005) except station 3. The water quality rating in this study showed that the water in the various station are of good quality (Chatterji and Raziuddin, 2002) since they are within the range of 26 – 50, while station 3 was of poor water quality because it belong to class 3 with the range, of 51 – 75. The order of quality of this water is station 4 > 1 > 2 > 3 meaning that station 4 is the best of the entire station while station 3 was poorest. This result showed that the water in the respective stations are good and safe for human consumption except station 3 which must be properly treated if it must be taken by man especially for drinking since it is unsafe for drinking.

Considering the water quality rating with respect to the parameters studied, pH showed that the water is not eutrophic and so suitable for human consumption. The pH values obtained in this study is in conformity with that reported by Davies *et al* (2006) in Elechi Creek but contradict the alkaline condition reported by Ambasht (1971), Swarnalatha and Narasingarao (1993), Shardendu and Ambasht (1988) in different water bodies.

Conductivity measurements can also be a useful tool for monitoring the inflow of saline water in estuaries and identifying sources of pollution such as mining or industrial waste or agricultural runoff (Manual, 2002). The electrical conductivity values obtained in this study which ranged between 53 and 28us/cm is considered high especially in stations 3 and 4 and could be attributed to the presence of high organic matter in the area. According to Murugesan *et al* (2006), electrical conductivity has to do with capability of water to transmit electric current and serves as essential tool to assess the water purity. Shinde *et al* (2011) opined that ability of water to transmit current depends on the ions, total concentration, mobility, valence, relative concentrations and temperature of measurement.
Alkalinity and chloride values in this study fall below the standard values which showed little level of organic pollution. Dissolved oxygen values in this study are within the permissive limit (5mg/l) except that of station 3. This observation could be attributed to high organic load in the station which is in conformity with the observations of Ghosh and George (1989), Swarnalatha and Narasinga (1993) and Venkateshwarlu (1993). According to Ameetha *et al* (2014), dissolved oxygen concentration regulates the distribution of aquatic biota which consist of flora and fauna. The BOD values are far below the permissive limit (5.0mg/l) which is in disconformity with the 28mg/l to 33mg/l reported by chatterjee (1992).

The water nutrients ($N0_3$, $P0_4$, $S0_4$) in this study shows that the water does not possess eutrophication features as confirmed by Harbel (2009). Flynn (2001) opined that high nutrients ($N0_3$, $S0_4$, $P0_4$) level often recorded in water bodies may be a reflection of direct discharge of pollutants among which domestic and wood wastes rank high directly into the creek.

Conclusion
The results of the physicochemical parameters and the water quality index showed that the present water in the respective stations are of good quality except station 3 which show little characteristics of eutrophication.

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