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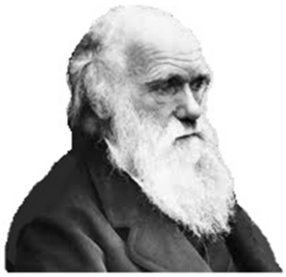

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Determination of Water Quality Index of Selected Water Bodies in Warri, Delta State, Nigeria

Ibiam Ntachiobi Ama[1], **Nwajei Godwin Ebichime**[1], **Agbaire Patience Odafe**[1] and **Verla Andrew Wirnkor**[2]

[1]Department of Chemistry, Delta State University, PMB 1 Abraka, Delta State, Nigeria

[2]Department of Chemistry, Imo State University, P.M.B.2000, Owerri, Imo State, Nigeria

E-mail address: excelokonkwo@gmail.com , verngo@yahoo.com

ABSTRACT

Water Quality index, indicating the water quality in terms of index number, offers a useful representation of overall quality of water for public or for any intended use, as well as in pollution abatement programmes and in water quality management. The present study was carried out to determine the Water Quality Index (WQI) of selected rivers in Warri, Delta State, using fourteen physicochemical parameters and on the basis of weighted Arithmetic Index in order to access the suitability of this water for consumption, recreation and other purposes. The parameters were measured monthly for one year at the six selected water bodies. In this study, WQI was determined by the analysis on the basis of various physicochemical parameters, such as pH, chlorides, electrical conductivity, dissolved oxygen, biochemical oxygen demand, total dissolved solid, total suspended solids, chlorides, sulfates, chemical oxygen demand, and oil/grease. Results obtained for the different sampling sites were found to fall within the WQI classifications – poor water (100-200) to unsuitable water or unfit (>300). There is, therefore, the need to periodically assess these water bodies to ensure the quality is suitable for the intended purpose.

Keywords**:** water quality index (WQI), arithmetic index, physicochemical parameter

1. INTRODUCTION

Water is a dynamic renewable natural resources. About 1.8 million people, mostly children die every year as a result of water related diseases. The fresh water is of vital

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importance to mankind, since it is directly linked to human welfare. The importance of water to man cannot be overemphasized since man can survive longer without food than without water. He requires it for his cooking, washing, sanitation, drinking, and for growing his crops and running his factories, apart from its industrial use water is a necessary social amenity. The provision of good quality water can help in eradicating water-borne diseases and in improving the general sanitation of Nigeria's towns and villages. Human physiology and man's continued existence depend very much on the availability of good drinking water quality. An average man (of 53 kg – 63 kg body weight), requires about 3 litres of water in liquid and food daily to keep healthy. This is the reason why water is regarded as one of the most indispensable substances in life and like air it is most abundant.

Provision of safe drinking water, especially in developing countries, has been tremendously affected by increase in human population. Unsafe water is one of the global public health threat, it places people at risk for a host of diarrheal and other water borne diseases, as well as chemical intoxication. Pollution of fresh water bodies all over the world causes a decrease in portability of water [1-7, 9-65]

Water quality is used to describe the condition of the water, including its chemical, physical and biological characteristics, usually with respect to its suitability for a particular purpose (i.e., drinking, swimming, or fishing. Water quality index (WQI) provides a single number that expresses the overall water quality at a certain location and time, based on several water quality parameters. The objective of WQI is to turn complex water quality data into information that is understandable and usable by the public. A number of indices have been developed to summarize water quality data in an easily expressible and easily understood format. The WQI, which was first developed by Horton in the early 1970s, is basically a mathematical means of calculating a single value from multiple test results. The index result represents the level of water quality in a given water basin, such as lake, river or stream. After Horton, a number of workers all over the world developed WQI based on rating of different water quality parameters. Basically, a WQI attempts to provide a mechanism for presenting a cumulatively derived, numerical expression defining a certain level of water quality.

The use of water quality index (WQI) simplifies the presentation of results of an investigation related to a water body as it summarizes in one value or concept a series of parameters analyzed. In this way, the indices are very useful to transmit information concerning water quality to the public in general, and give a good idea of the evolution tendency of water quality to evolve over a period of time. A single WQI value makes information more easily and rapidly understood than a long list of numerical values for a large variety of parameters. Inadequate management of water resources has directly or indirectly resulted in the degradation of hydrological environment. Therefore, continuous periodical monitoring of water quality is necessary for effective water resource management practices.

The present study is to serve as a baseline study, since there is no literature regarding the water quality index in this region before now. The present investigation was carried out to compute the Water Quality Index (WQI) in order to assess the suitability of water from different selected water bodies in Warri.

The main objectives of the study were to determine water quality parameters *viz*., pH, chlorides, electrical conductivity, dissolved oxygen, biochemical oxygen demand, total dissolved solid, total suspended solids, chlorides, sulfates, chemical oxygen demand, oil/grease, and some heavy metals, as recommended by the World Health Organization.

These parameters will then be used to compute the Water Quality Index (WQI) in order to assess the suitability of water from different selected water bodies. Finally, an interpretation of results will enable recommendations for future work and provide guidelines for other water sources.

2. MATERIAL AND METHODS

2. 1. Description of Study Area

The study was carried out at six selected water bodies in Warri, Delta State, Nigeria (**Table 1**). The city of Warri is an oil hub in south-south Nigeria. It shares boundary with Ughelli /Agbarho, Sapele, Okpe, Udu, and Uvwie. It houses Warri Refinery and Petrochemicals located at Ekpan with the majority of International and local oil companies having their operational offices there. One of the major seaports is located at Ugbuwangue, and Delta Steel Company located at Aladja, and Otorogu Gas plants at Otor-Udu.

Table 1. Sample Locations and coordinates of the study

S/NO.		LOCATION	COORDINATES
1.	SW1	WORKSON NIG LTD JETTY	N5^{O}31^{I} 49^{II} E5^{O}42^{I}43^{II}
2.	SW2	OGUNU	N5^{O}30^{I} 52^{II} E5^{O}44^{I}0^{II}
3.	SW3	UGBUAWANGUE	N5^{O}32^{I} 43^{II} E5^{O}42^{I}31^{II}
4.	SW4	ENERHEN	N5^{O}32^{I} 42^{II} E5^{O}47^{I}48^{II}
5.	SW5	NPA	N5^{O}30^{I} 52^{II} E5^{O}43^{I}59^{II}
6.	SW6	OGBEIJAW	N5^{O}30^{I} 43^{II} E5^{O}44^{I}43^{II}

2. 2. Sample Collection

Table 2. Mean values of physicochemical parameter values for all sampling points (All values, except pH and Electrical conductivity, are in (mg/l)

Parameter	Season	S1	S2	S3	S4	S5	S6
pH	Wet	6.77	6.84	6.79	6.18	7.07	6.87
	Dry	7.01	7.02	7.06	7.06	7.13	7.16
	Average	6.87	6.90	6.90	6.64	7.06	6.95
E/Cond	Wet	131.87	111.36	152.44	29.99	90.49	56.87

	Dry	178.46	168.34	151.48	71.98	67.68	74.48
	Average	151.3	110.10	152.02	47.08	81.00	64.21
TDS	Wet	86.00	73.49	97.10	18.88	56.77	74.48
	Dry	109.38	57.88	79.72	38.5	35.95	39.91
	Average	90.33	67.00	89.86	27.08	48.09	38.44
TSS	Wet	3.74	12.31	5.07	4.66	5.86	4.01
	Dry	9.14	12.00	6.30	9.80	10.30	9.06
	Average	5.99	12.19	5.56	7.06	7.73	6.36
BOD_5	Wet	1.80	1.41	1.91	1.51	1.87	1.34
	Dry	1.74	2.41	2.99	1.82	2.50	1.69
	Average	1.78	1.73	2.37	1.64	2.13	1.99
DO	Wet	5.21	4.53	4.66	4.91	5.19	4.31
	Dry	5.38	5.28	5.34	5.42	6.24	5.42
	Average	5.28	4.93	5.15	4.92	5.54	4.78
Cl-	Wet	27.32	15.67	25.65	12.03	12.81	13.19
	Dry	49.86	24.56	30.22	16.66	15.95	15.97
	Average	36.72	19.37	27.56	13.96	14.12	14.35
SO_4^{2-}	Wet	6.20	21.77	16.51	11.77	18.26	16.40
	Dry	7.66	7.30	5.76	4.55	4.81	4.72
	Average	12.64	15.74	13.19	8.72	12.65	11.79
COD	Wet	98.64	86.01	54.70	96.60	93.04	82.47
	Dry	51.0	94.80	50.1	159.60	62.5	61.70
	Average	30.79	89.00	52.80	122.86	80.46	73.81
O/G	Wet	0.83	0.79	0.40	0.90	0.39	0.80
	Dry	1.26	1.13	1.21	1.83	1.02	2.03
	Average	1.01	0.88	0.72	1.29	0.65	1.31
Pb	Wet	0.02	0.03	0.04	0.01	0.04	0.04

	Dry	0.02	0.01	0.05	0.02	0.01	0.03
	Average	0.02	0.02	0.04	0.02	0.02	0.03
Fe	Wet	0.96	1.21	0.96	0.72	1.10	0.99
	Dry	1.31	1.26	1.12	1.09	1.08	0.91
	Average	1.11	1.23	1.03	0.87	1.09	0.90
Zn	Wet	0.13	0.08	0.08	0.18	0.05	0.07
	Dry	0.15	0.15	0.11	0.25	0.12	0.10
	Average	0.11	0.15	0.13	0.21	0.12	0.43
Mn	Wet	0.17	0.14	0.20	0.17	0.11	0.15
	Dry	0.16	0.19	0.12	0.14	0.12	0.16
	Average	0.17	0.10	0.24	0.19	0.11	0.12

Surface water samples from six different selected water bodies (SW1-SW6) in Warri were collected at interval of one year from November 2012-October 2013 (**Table 2**). All plastics and glasses utilized were pre-treated by washing with dilute (0.05 M) HCl and later rinsed with distilled water. They were air-dried in a dust free environment. At the point of collection, the samples were rinsed with relevant samples twice, then filled with samples and corked tightly. Various physicochemical parameters of the water samples and the heavy metals were analyzed by following the standard methods of APHA (2005).

2. 3. Calculating of Water Quality Index (WQI)

Calculating of water quality index is to turn complex water quality data into information that is understandable and useable by the public. Therefore, WQI is a very useful and efficient method which can provide a simple indicator of water quality and it is based on some very important parameters.

In the current study, WQI was calculated by using the Weighted Arithmetic Index method, as described by [8]. In this model, different water quality components are multiplied by a weighting factor and are then aggregated using simple arithmetic mean.

For assessing the quality of water in this study, firstly, the quality rating scale (Q_i) for each parameter was calculated by using the following equation:

$$Q_i = (V_{actual} - V_{ideal} | V_{\ standard} - V_{ideal}) \times 100 \ldots\ldots\ldots 1$$

where:

Q_i = Quality rating of i-th parameter for a total of n water quality parameters
V_{actual} = Actual value of the water quality parameter obtained from the laboratory analysis

V_{ideal} = Ideal value of that water quality parameter can be obtained from the standard tables
V_{ideal} for pH = 7 and for other parameters, it is equaling to zero, but for DO, V_{ideal} = 14.6 mg/l
$V_{standard}$ = Recommended WHO standard of the water quality parameter.

Then, after calculating the quality rating scale (Q_i), the relative (unit) weight (W_i) was calculated by a value inversely proportional to the recommended standard (S_i) for the corresponding parameter using the following expression;

$$W_i = I/ S_i \ldots\ldots\ldots\ldots\ldots 2$$

where:

W_i = Relative (unit) weight for nth parameter, S_i = Standard permissible value for n-th parameter, I = Proportionality constant.

That means, the Relative (unit) weight (*WI*) to various water Quality parameters are inversely proportional to the recommended standards for the corresponding parameters.

Finally, the overall WQI was calculated by aggregating the quality rating with the unit weight linearly by using the following equation:

$$\mathrm{WQI} = \Sigma Q_i W_i / \Sigma W_i \ldots\ldots\ldots\ldots 3$$

where:

Q_i is quality rating and W_i is a relative weight.

In general, WQI is defined for a specific and intended use of water. In this study the WQI was considered for human consumption or uses and the maximum permissible WQI for the drinking water was taken as 100 score. Grades of water quality index (WQI) and status of water quality were categorized as WQI <50 – Excellent, WQI 50-100 – Good water, WQI of 100-200 – Poor water, WQI of 200-300 is very poor water, while WQI >300 is considered unsuitable (unfit) for drinking.

Water quality index for all six rivers were ranged from 150 to 370 and could be described as generally ranging from poor water to unsuitable for drinking. The mean value of WQI (215) showed that all rivers could be characterized as very poor water for human use. In the dry season, WQ1 for SW_3 was the highest (**Fig.** 1), while SW_2 was the lowest. The order of decreasing WQI in the dry season was $SN_3 < SW_4 < SW_6$, SW, $SW_5 < SW_2$..

In the dry season there are non-off into these rivers, and so this could reduce amount of the WQ1 for dry season revealing that SW_6 was the highest, while SW_4 was the least. The trend of decreasing WQ1 for all six rivers was SW_6, $SW_5 < SW_3 < SW_1 < SW_2 < SW_4$ when yearly values of WQ1 assessed by determining it was observed that $SW_6 < SW_3 < SW_4 < SW_2 < SW_5 < SW_1$.

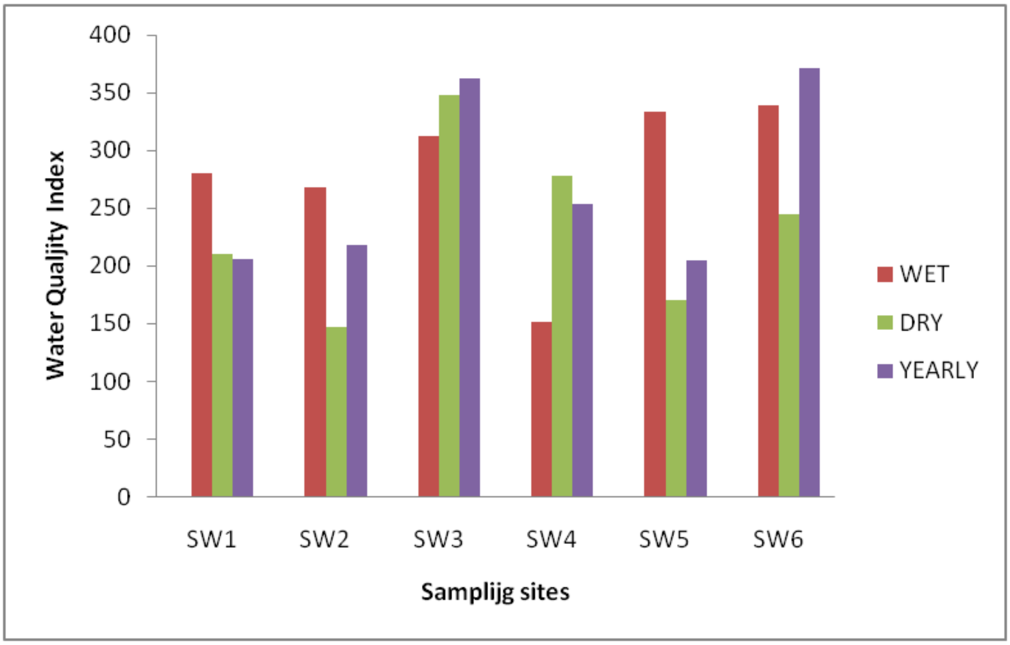

Figure 1. Summary of water quality index of different locations and seasons

Table 3. A typical calculation of WQI for the location SW1 during Wet Season 2013 (All values except pH and electrical conductivity are in (mg/l)

Parameters	Actual measured values	WQ standard value (*S*i)	Relative weight (*W*i)	Quality rating (*Q*i)	Weighted values
pH	6.77	6.5-9.2	0.1087	–10.45	–1.136
E/COND	131.87	1400	0.0007	0.42	0.007
TDS	86.00	1200	0.0008	7.17	0.006
TSS	3.74	<30	0.03	12.47	0.374
BOD_5	1.84	5	0.20	36.80	7.36
DO	5.21	5	0.20	97.81	19.56
Cl^-	27.31	250	0.004	10.92	0.043
SO_4^{2-}	16.20	500	0.002	3.24	0.0065
COD	98.64	<5	0.20	1972.8	39.46
O/G	0.83	10	0.10	8.3	0.83

Pb	0.02	0.01	100	200	20,000
Fe	0.96	0.3	3.33	3,200	10,656
Zn	0.13	0.05	20	260	5,200
Mn	0.17	0.1	10	170	1,700
			ΣWi 134.1762		$\Sigma Wi \cdot Qi$ 37624.78

3. CONCLUSION

All rivers studied showed poor or very unfit water for human use. However, WQ1 was higher in the rainy season than in the dry season. The weighted arithmetic water quality (WQ1) has been used to categorize the six water bodies, according to their suitability for human use. It is also noted that WQ1 has summarized the many water parameters into an easily interpreted index. However, it is worth mentioning that WQ1 may not be completely a true representation of water quality of river and so monitoring and assessment of water bodies is important to give a more appropriate status of a river over longer periods of time.

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