Asian Journal of Environment & Ecology

Volume 23, Issue 9, Page 96-106, 2024; Article no.AJEE.121867
ISSN: 2456-690X

Comparative Analysis of Water Quality Index (WQI) from Selected Water Bodies in Different Regions of Southeast Nigeria

Ibeaja, Adamma Chinyere E. [a*] and Ugorji, Chinonso Chiagoziem [b]

[a] Abia State University, Uturu, Abia State, Nigeria.
[b] Department of Environmental Resource Management, Abia State University, Uturu, Abia State, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript

Article Information

DOI: https://doi.org/10.9734/ajee/2024/v23i9601

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/121867

Original Research Article

Received: 17/06/2024
Accepted: 19/08/2024
Published: 05/09/2024

ABSTRACT

This study was carried out to compare the water quality index of selected water bodies in Okigwe, Imo State, Nigeria. Water samples were collected from two streams, Ihiku and Iyiechu (upstream and downstream) and the experimental research was used for this study. Several physico-chemical characteristics were analyzed in line with W.H.O, USEPA, S.O.N. The results obtained from the physico- chemical parameters ranged as follows: air shade temperature (23.3-25.0), pH (5.7-6.8), Electrical conductivity (15.5-20.4), Total hardness (33-40.5), Alkalinity (55.5-70.8), Biological

**Corresponding author: E-mail: adaibeaja@gmail.com;*

Cite as: *Ibeaja, Adamma Chinyere E., and Ugorji, Chinonso Chiagoziem. 2024. "Comparative Analysis of Water Quality Index (WQI) from Selected Water Bodies in Different Regions of Southeast Nigeria". Asian Journal of Environment & Ecology 23 (9):96-106. https://doi.org/10.9734/ajee/2024/v23i9601.*

Oxygen Demand (2.6-5.0), Dissolved Oxygen (6.5-8.0), Sulphate (1.8-5.7), phosphate (5.2-7.0) and silica (0.66-0.78). The result showed that there were variations in the concentration as a result of anthropogenic activities of man. The water quality index was also checked and compared to standards. The Pearson's Correlation Moment was performed at 0.01% level. The result showed that values obtained were statistically significant. However, adequate treatment facilities that purify sewage prior to discharge or disposal should be adopted.

Keywords: Water quality index; comparative; pathogenic organisms; assessment; air shade temperature; sewage treatment.

1. INTRODUCTION

"Water is an excellent solvent for a wide variety of substances both mineral and organic; as such it is widely used in industrial processes, in cooking and washing. Water, ice and snow are also central to many sports and other forms of entertainment, such as swimming, pleasure boating, boat racing, surfing, sport fishing, diving, ice skating and skiing" [1].

"The quality of river and stream water is very sensitive to anthropogenic influences urban, industrial and agricultural activities, increasing consumption of water resources as well as natural processes changes in precipitation inputs, erosion, weathering of earths crustal material degrade the surface waters and impair their use for drinking, industrial, agricultural, recreation or other purposes" [2]. "All of the constituents of river water originate from dissolution of the earth's rocks. The dissolution of rocks in the catchment area is a major determinant of river water chemistry locally as well, but this varies with geology and with the magnitude importance in streams" [3].

"Cloud forms precipitation in the form of rain and aerosols in the form of fog. Clouds consist of suspended droplets of water and ice, its solid state. When finely divided, crystalline ice may precipitate in the form of snow. The gaseous state of water is steam or water vapor. Water covers about 71% of the Earth's surface, mostly in seas and oceans (about 96.5%)" [4].

"Water plays an important role in the world economy. Approximately 70% of the freshwater used by humans goes to agriculture" [5]. "Fishing in salt and fresh water bodies is a major source of food for many parts of the world, providing 6.5% of global protein" [1].

It has been estimated that once pollution enters the subsurface environment, it may remain concealed for many years, becoming dispersed over wide areas of groundwater aquifer and rendering groundwater supplies unsuitable for consumption and other uses.

"Therefore, understanding the potential influences of human activity on ground water quality is important for protection and sustainable use of ground water resources" [6].

Water contamination containing toxic substances are generated by a wide variety of chemical processes, as well as by a number of other common household and agricultural applications. In this context, galvanized roofing sheets and their chemicals are toxic recalcitrant compounds, which may accumulate in the environment. The inadequate management of these effluents can have harmful consequences to human health [7].

1.1 Statement of Problem

"Water pollution can be defined as the contamination of a stream, river, lake, ocean or any other stretch of water, depleting water quality and making it toxic for the environment and humans" [8]. "Human activity is primarily responsible for water pollution, even if natural phenomenon - such as landslides and floods - can also contribute to degrade the water quality" [9]. "Water pollution truly harms biodiversity and aquatic ecosystems. The toxic chemicals can change the color of water and increase the amount of minerals - also known as eutrophication - which has a bad impact on life in water. Thermal pollution, defined by a rise in the temperature of water bodies, contributes to global warming and causes serious hazard to water organisms" [10]. "Water pollution has very negative effects on public health. A lot of diseases result from drinking or being in contact with contaminated water, such as diarrhea, cholera, typhoid, dysentery or skin infections" [11]. "In zones where there is no available drinking water, the main risk is dehydration. Wastewater treatment consists of removing pollutants from wastewater through a physical, chemical or biological process. The more efficient these processes are, the cleaner the water becomes" [12]. It is based on these mentioned uncertainties that the study assesses the water quality index and physico-chemical characteristics of the streams, Ihiku and Iyiechu so as to answer and proffer solutions to the unanswered questions posed by the people.

1.2 Aim and Objectives of the Study

The study aimed at a comparative assessment of the water quality of some selected streams in Okigwe Imo State, Nigeria. The specific objectives were:

1. Determine the physico-chemical characteristics of the water samples.
2. Assess the water quality index (WQI) of the water samples (streams).
3. Compare the quality of water (based on the WQI) of each water sample with standards.

1.3 Hypothesis

$\mathbf{H_o}$ = There is no statistically significant difference between the samples and the parameters.
$\mathbf{H_1}$ =There is.

2. METHODOLOGY

2.1 Research Design

The experimental research design was used for this study**.** The water samples used for this study were collected from Ihiku and Iyiechu streams respectively. The water samples were collected in four clean dry brown plastic containers in a way that the samples won't mix with each other. The plastic containers were labeled appropriately using a marker and transported to the laboratory for further analysis.

2.2 Sampling Technique

The systematic random sampling technique was used for the collection of samples in the upstream and downstream and a total of eight samples were used for the study.

2.3 Variables

2.3.1 The experimental method

For this study, four sampling points (2 upstream and 2 downstream) were sampled. The samples were collected between 7am-9am before the water was disturbed. The plastic containers and the reagent bottles used for the samples collection were washed, dried and labeled before they were taken to the site. The brown and the transparent sampling bottles were used for biochemical oxygen demand and dissolved oxygen (BOD and DO) respectively and the plastic containers were used for collection of water for other physico-chemical analyses. Water samples for each of the four stations were collected, the brown bottles were wrapped with foil paper and masking tape to exclude light, thereby preventing further photosynthesis after the sample collection. The bottles were rinsed with water at the specific sampling location before the samples were collected. Dissolved Oxygen was fixed in transparent bottles using 2ml of 40- 50% $MnSO_4$ reagent (Winkler 1 reagent) and 2ml of alkaline iodide solution (Winkler II reagent) and they were mixed vigorously by inversion, the collected water sample were transported to the laboratory for further analysis. The brown bottles were fixed after 5 days of incubation. A total of eight water samples were used for this study. Physico-chemical parameters such as air shade temperature, pH, Electrical conductivity, Total hardness, Dissolved Oxygen, Biological Oxygen Demand, Nitrate, Alkalinity, Phosphate, Sulphate and Silica were analyzed using Atomic Absorption Spectrophotometer, Digital meters and titration methods. The results obtained were compared with different standards threshold for drinking water quality.

2.3.2 Water quality index

Water Quality Index (WQI) is considered as the most effective method of measuring water quality. A number of water quality parameters are included in a mathematical equation to rate water quality, determining the suitability of water for drinking [13].

Also, the water quality index (WQI) of each community studied was determined to ascertain the suitability of the water for domestic purposes.

In the study, for the calculation of water quality index, five (5) parameters were used. The WQI was calculated using the standard for drinking water quality. In this study, the water quality index as per weighted arithmetic method of [14] was used for calculating the water quality index by using the most commonly measured water quality variables. The water Quality Index method classified the water quality according to the degree of purity, using the following equation:

$$WQI= \sum \frac{QiWi}{Wi}$$

$$Qi=100[(\frac{Vi-Vo}{Si-Vo})]$$

Where:

Vi = Estimated concentration of the parameter in the analyzed water.
Vo= Ideal value of this parameter in pure water (0 for all other parameters except pH = 7.0 and DO = 14.6mg/l). Si= Recommended standard value of the parameter.

The unit weight (Wi) for each water quality parameter is calculated by using the following formula:

$$Wi=k/Si=1/Si$$

Where k- proportionality constant

3. RESULTS AND DISCUSSION

3.1 Determination of the Physico-Chemical Parameters

The results of the physico-chemical analysis of the water samples collected and analyzed for Ihiku and Iyiechu is shown in Table 1 while the comparison and calculated water quality index (WQI) for each of the water samples is shown in Tables 2,3,4,5 and 6 with a summary of water quality index (WQI) in Table 7.

The air shade temperature of Ihiku and Iyiechu streams was determined using a mercury-in-glass thermometer and the values obtained were 24.0°C for upstream, and 25°C for downstream for Ihiku while the Iyiechu stream had 23.3°C for upstream and 23.5°C for downstream. The temperature ranges between 23.0oC – 25.0oC. The values of air shade temperature of the streams were 24ºC, 25ºC, 23.3ºC, 23.5ºC for station 1 and 2 respectively and the mean value of the surface water temperature was 23.3°C as compared to Alabaster and Lloyd [15] who reported that temperature of natural inland waters in the tropics generally varies between 25°C and 35°C. Also, Dibia [16] and Jamabo [17] reported a temperature range between (25°C to 27°C) and 27°C and 30°C respectively in the Upper Bonny River of Niger Delta. These values were within the recommended range by FEPA as shown in Table 1 and Fig. 3 respectively.

The PH values of the streams, Iyiechu and Ihiku fell within the range 5.7-6.8 for station 1 and 2 respectively. The PH of the streams (samples) fell within the W.H.O, EU, S.O.N and USEPA acceptable limits which was is between 6.5-6.595. The values are displayed on Table 1 and Fig. 4 respectively.

The Electrical Conductivity of the streams ranges between were 15.5us/cm- 20.5us/cm for station 1and 2 respectively and the values obtained were within the W.H.O, S.O.N and USEPA standards as shown in Table 1 and Fig. 1 respectively. The values of the conductivity relate with its hardness which indicates that the harder the hardness, the higher the conductivity.

Total alkalinity of the streams ranged from 55.5mg/l - 70.8mg/l which was within the stipulated limit as compared to W.H.O, S.O.N and USEPA as shown in Table 1 and Fig. 2 respectively.

The concentration of Dissolved Oxygen(DO) from the streams, Iyiechu and Ihiku ranged from 6.5-8.0mg/l which was in line with the standards as documented by W.H.O, EU and FEPA. The dissolved oxygen is an important parameter as it helps in oxidation of organic matter [18].

The total hardness value ranged from 33-40.5 mg/l and was within the acceptable W.H.O, E.U, S.O.N and U.S.E.P.A range as shown in Table 1. This implies that the water is soft and ideal for domestic purposes and this range was recorded for some areas such as Imo and Abia States respectively [19].

The sulphate and phosphate levels ranged from 1.8-5.7mg/l and 5.2-7.0 mg/l respectively. From the result on Table 1, it shows that sulphate fell within the compared standards while phosphate didn’t comply. This could be as a result of anthropogenic activities carried out at the river banks thereby increasing the phosphate level.

Furthermore, the water index values obtained from the water samples were 127.37, 96.45,112.67 and 133.12 for the Ihiku and Iyiechu, both upstream and downstream. According to the water quality index rating, the water samples analyzed are not suitable for drinking or cooking based on the values obtained as shown on Table 7 and compared with the rating on Table 8.

The chemical properties of the water samples were analyzed as shown in Fig. 5.

Table 1. Results of physico-chemical analysis of the samples (Iyiechu and Ihiku)

S/No	Parameters	Ihiku station 1	Ihiku station 2	Iyiechu station1	Iyiechu station 2
1	Air shade temperature °C	24.5°C	25°C	23.3	23.5
2	Ph	5.7	5.8	6.7	6.8
3	Dissolved Oxygen	6.8	6.5	7.6	8
4	Biochemical Oxygen Demand	2.6	3. 5	4.8	5.0
5	Electrical Conductivity	15.5	18.5	20.5	20.4
6	Total Hardness	40.5	39.5	33.4	33
7	Total Alkalinity	56.6	55.5	70.8	68.5
8	Total Dissolved Oxygen	0.3	0.2	0.2	0.3
9	Calcium Hardness	15.6	18.5	20.6	20.4
10	Phosphate	6.5	7.0	5.2	5.5
11	Sulphate	5 7	2.7	1.8	4.5

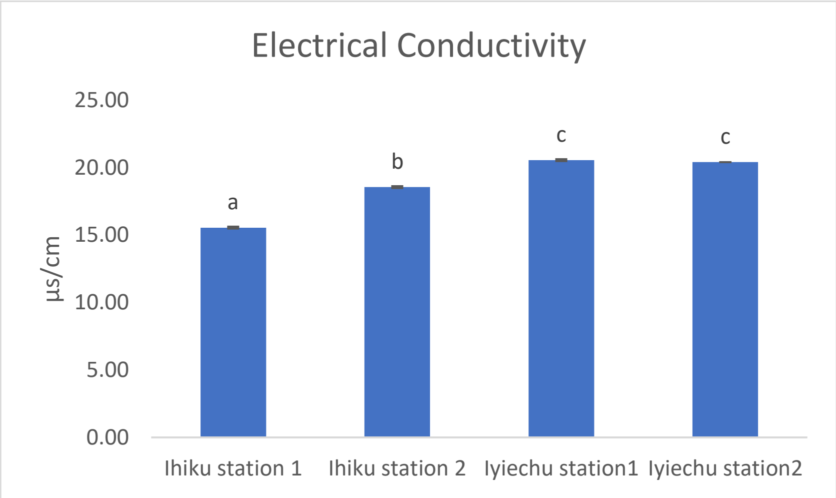

Fig. 1. Electrical Conductivity

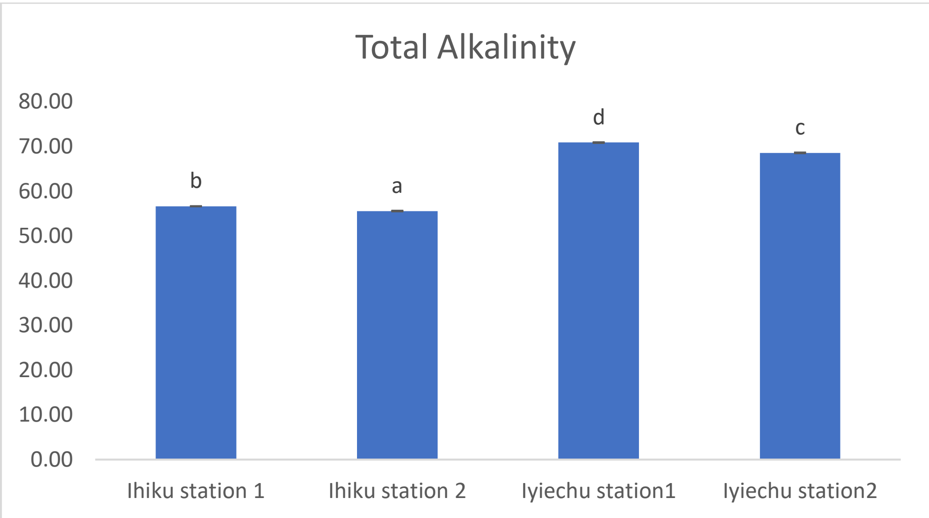

Fig. 2. Total alkalinity

Table 2. Comparison between the physico-chemical parameters of the two samples (Iyiechu & Ihiku) as compared with W.H.O, EU, S.O.N, USEPA and FEPA

S/no	Parameters	Ihiku station 1	Ihiku station 2	Iyiechu station 1	Iyiechu station 2	W.H.O	E.U	S.O.N	U.S.E.P.A	FEPA
1	Air shades temperature (°C)	24.5	25	23.3	23.5	25	-	28	-	20-35
2	pH	5.7	5.8	6.7	6.8	6.5-85	6.583	6.583	6.595	5.00-9.00
3	Dissolved Oxygen (DO) (mg/L)	6.8	6.5	7.6	8	50	50	-	-	>1.00
5	Electrical conductivity (µs/cm)	15.5	18.5	20.5	20.4	100	-	1000	2500	20.00-1500.00
6	Total hardness (mg/L)	40.5	39.5	33.4	33	150	500	150	2500ppm	-
7	Alkalinity ($mg^{/-1}$)	56.6	55.5	70.8	68.5	25	-	100	296	-
8	Calcium (mg/L)	15.6	18.5	20.6	20.4	100				
9	Phosphate (mg/L)	6 5	7.0	5.2	5.5	0.3mg/l	0.1	-	1.8mg/l	0.01-3.0
10	Sulphate (mg/L)	5. 7	2.7	1.8	4.5	100	-	50	-	1000
11	Biochemical Oxygen Demand	2.6	3.5	4.8	5.0	40	40		5.0	10-20
12	Silica (mg/L)	0.75	0.78	0.66	0.68	25	-	-	-	-

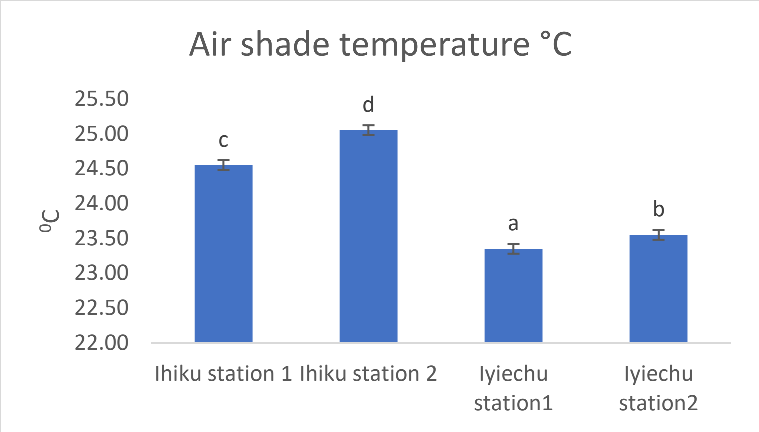

Fig. 3. Air shade temperature

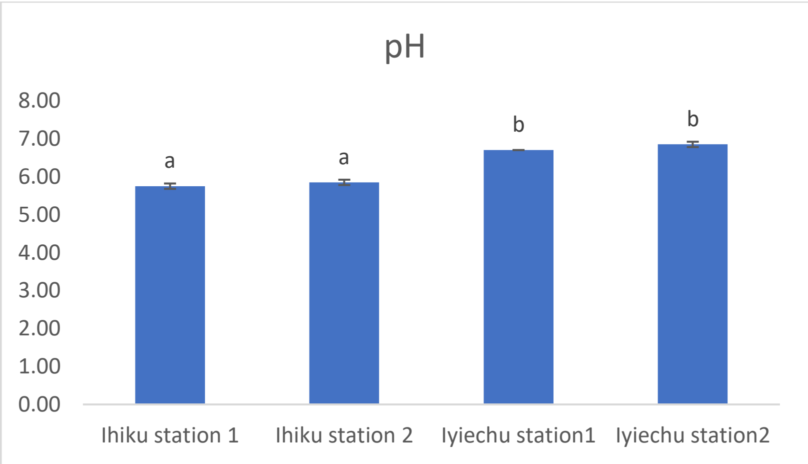

Fig. 4. pH

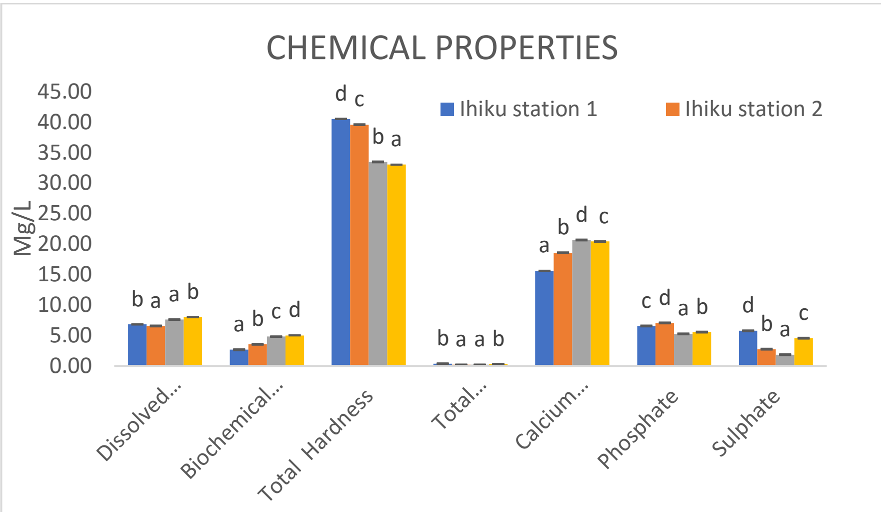

Fig. 5. Chemical properties

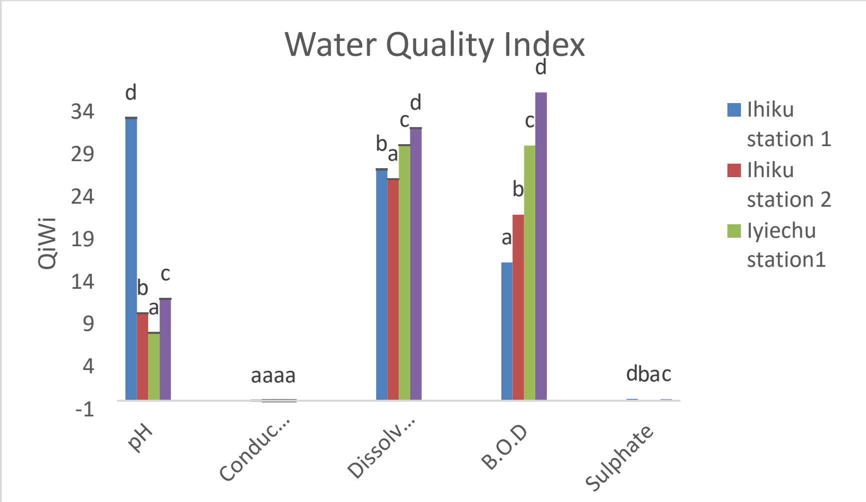

Fig. 6. Water quality index

3.2 Comparison between the Physico-chemical Parameters of the Two Samples (Iyiechu & Ihiku)

This was carried out in order to compare the values of the physico- chemical parameters obtained from the two samples (Iyiechu and Ihiku) and compared to environmental standards. The result obtained is displayed on Table 2.

3.3 Water Quality Index of the Sample

The results obtained from the water quality index for Iyiechu and Ihiku is displayed on Table 3.

∑Wi =0.604

ΣQiWi =76.93

WQI= $\sum \frac{QiWi}{Wi}$ =127.37

Where: Vi =Estimated concentration of the parameter in the analyzed water. Si = Standard value of the parameter, Vo= Ideal value of the parameter in pure water (0 for all other parameters except pH and Dissolved Oxygen=7.0 and 14.6mg/l respectively). Qi= 100(Vi-Vo/Si-Vo), Wi= Unit weight (k/Si=1/Si).

∑Wi =0.604

ΣQiWi =58.259

WQI = Σ $\frac{QiWi}{Wi}$ = 96.45

∑wi =0.604

ΣQiwi =68.054

WQI = Σ $\frac{QiWi}{Wi}$ = 112.67

Table 3. Water quality index for station 1(Ihiku)

S/No	Parameters	Vi	Si	Qi	Wi	QiWi
1	Ph	5.7	7.5	250	0.133	33.25
2	Conductivity	15.5	1000	1.55	0.001	0.0015
3	Dissolved Oxygen	6.8	5.0	136	0.200	27.2
4	B.O.D	2.6	4.0	65	0.250	16.25
5	Sulphate	5.7	50	11.4	0.020	0.228

Table 4. Water quality index for station 2(Ihiku)

S/no	Parameters	Vi	Si	Qi	Wi	Qwi
1	Ph	5.8	7.5	77.3	0.133	10.28
2	Conductivity	18.5	1000	1.85	0.001	0.0018
3	Dissolved Oxygen	6.5	5.0	130	0.200	26
4	BOD	3.5	4.0	87.5	0.250	21.87
S	Sulphate	2.7	50	5.4	0.020	0.108

Table 5. Water quality index for station 3(Iyiechu)

S/no	Parameters	Vi	Si	Qi	Wi	QiWi
1	Ph	6.7	7.5	60	0.133	7.98
2	Conductivity	20.5	1000	2.05	0.001	0.0020
3	Dissolved Oxygen	7.6	5.0	152	0.200	30.0
4	BOD	4.8	4.0	120	0.250	30
5	Sulphate	1.8	50	3.6	0.020	0.072

Table 6. Water quality index for station 4 (Iyiechu)

S/no	Parameters	Vi	Si	Qi	Wi	QiWi
1	Ph	6.8	7.5	90	0.133	11.97
2	Conductivity	20.4	1000	2.4	0.001	0.0024
3	Dissolved Oxygen	8	5.0	160	0.200	32
4	BOD	5.8	4.0	145	0.250	36.25
S	Sulphate	4.5	50	9	0.020	0.18

Table 7. Water quality rating for the 4 stations

Stations	WQI value	Rating water quality	Grading
Ihiku station 1	127.37	Not suitable for drinking purposes	E
Ihiku station 2	96.45	Very poor water quality	D
Iyiechu station	112.67	Not suitable for drinking purposes	E
Iyiechu station 2	133.12	Not suitable for drinking purposes	E

Table 8. Water quality rating as per weight arithmetic water quality index method

WQI	Rating of water quality	Grading
0-25	Excellent water	A
26-50	Good water quality	B
51-75	Poor water quality	C
76-100	Very poor water quality	D
Above 100	Unsuitable for drinking.	E

Yogendra and Puttaiah 2008

Table 9. Correlations between the samples using the Pearson's Correlation Moment

		MOIST (Ihiku) A1	MOIST (Ihiku) A2	MOIST (Iyiechu)B1	MOIST (Iyiechu) B2
MOIST A1	Pearson Correlation	1	-1.000**	.107	.045
	Sig. (2-tailed)		.000	.893	.955
	N	4	4	4	4
MOIST A2	Pearson Correlation	-1.000**	1	-.107	-.045
	Sig. (2-tailed)	.000		.893	.955
	N	4	4	4	4
MOISTB1	Pearson Correlation	.107	-.107	1	.993**
	Sig. (2-tailed)	.893	.893		.007
	N	4	4	4	4
MOIST B2	Pearson Correlation	.045	-.045	.993**	1
	Sig. (2-tailed)	.955	.955	.007	
	N	4	4	4	4

***. Correlation is significant at the 0.01 level (2-tailed)*

$\sum Wi = 0.604$

$\Sigma QiWi = 80.4024$

$QWI = \Sigma \frac{QiWi}{Wi} = 133.12$

3.4 Statistical Analysis

Statistical analysis of data obtained in this research was generated using the IBM SPSS statistic as shown in Table 7. The Pearson's Correlation Moment was performed at 0.01% level. The result showed that values obtained were statistically significant.

4 CONCLUSION AND RECOMMENDATIONS

Most of the physical and chemical parameters of water were studied as a general characterization of the study area. The study carried out showed the water samples analyzed were polluted or contaminated as a result of anthropogenic activities such as washing, dumping of refuge and other illegal activities.

There should be need to monitor the activities that take place in these water bodies.

Following the findings of this research, the following recommendations were made:

- Personal hygiene should be adopted by everyone using natural water, that is, water obtained from any of the natural sources should be boiled or treated before consumption.
- Water purification method that provides safe drinking water should be made available by government in order to avoid outbreak cause by pathogenic organism found in water.
- The government should make more sacrifices to provide adequate treatment facilities that purify sewage prior to discharge or disposal, so as to save our drinking water from continuous pollution.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Troell M, Naylor RL, Metian M, Beveridge M, Tyedmers PH, Folke C, Arrow KJ, Barrett S, Crépin A, Ehrlich PR, Gren A. Does aquaculture add resilience to the global food system. Proceedings of the National Academy of Sciences. 2014; 111(37):13257–13263.
2. Kim JY, An KG. Integrated ecological river health assessments, based on water chemistry, physical habitat quality and biological integrity. Water. 2015;7:6378–6403.
3. Beechie T, Imaki H, Greene J, Wade A, Wu H, Pess G. Restoring salmon habitat for changing climate. River Research and Applications. 2013;29:939–960B.
4. Gleick PH. Water in crisis: A guide to the world's freshwater resources. Oxford University Press. 2013;13.
5. Baroni L, Cenci L, Tettamanti M, Berati M. Evaluating the environmental impact of various dietary patterns combined with different food production systems. European Journal of Clinical Nutrition. 2017;61(2):279–286.
6. Okeola FO, Kolawole OD, Ameen OM. Comparative study of physic-chemical parameters of water from a River and it's surrounding wells for possible interactive effect. Advances in environmental Biology. 2020;4(3):336-344.
7. Perakis F, Amann-Winkel K, Lehmkühler F, Sprung M, Mariedahl D, Sellberg JA. Diffusive dynamics during the high-to-low density transition in amorphous ice. Proceedings of the National Academy of Sciences of the United States of America. 2017;13(8–9):667–677.
8. Abdulsalam A, Zubairu SM, Hussaini A. Analysis of water quality of selected wells in Gonin- Gora, Kaduna State. A paper presented at the Association of Nigerian Geographers (ANG) Conference, held in Nasarawa State University; 2017.
9. Charles KJ, Howard G, Villalobos P, Elena G, Joshua A. Infrastructure alone cannot ensure resilience to weather events in drinking water supplies. Science of the Total Environment. 2022;813:151876.
10. Vivian EL, Obasi MT, Jerry P, Ali AY, Sodangi PA, Daleong MH, Giwa CY, Yakubu MT. Analysis of Groundwater Quality Around Some Dumpsites in Jos Metropolis, Plateau State, Nigeria. Kaduna

State University Environmental Science Journal. 2020;1(2):63-74.
11. Aboh AE, Giwa JF, Giwa A. Microbiological assessment of well waters in Samaru, Zaria, Kaduna State, Nigeria. Journal of Annals of African Medicine. 2015; 14(12):32-38.
12. Salmiati S, Arman NZ, Salim MR. Integrated approaches in water quality monitoring for river health assessment: scenario of Malaysian River. Water Quality; 2017.
13. Ochuko U, Origbo T, Ohwohere AO, Ewhuwhe EJ. A comperative assessment of water quality index and suitability of river Ase for domestic water supply in urban and rural communities in Southern Nigeria International Journal of Humanities and Social Sciences. 2014;4(1):234-245.
14. Tyagi S, Sharma B, Singh P, Dobhal R. Water quality assessment in terms of water quality index. American Journal of Water Resources. 2013;1(3):34-38.
15. Alabaster JS, Lloyd R. Water quality criteria for fresh water fish. Butter worth's London, U.K. 1980;297.
16. Dibia AEN. Effect of biotope difference on aquatic macrophytes along mini-Chindah stream in Port Harcourt, Rivers State. M.Sc thesis Rivers State University of Science and Technology, Port Harcourt, Nigeria. 2006;120.
17. Jamabo NA. Ecology of *Tympanotonus fuscatus* in the mangrove swamps of upper bunny river, Niger Delta, Nigeria. Ph.D thesis Rivers State University. 2008;340.
18. Federal Environmental Protection Agency (FEPA). Guidelines and standards for environmental pollution control in Nigeria. 2010;327.
19. Nwadiaro CS, Oranusi NA, Umeham SN. Preliminary of the drinking water quality of some areas in Imo and Abia States. 3rd conference of water pollution held at Nigeria stop oil company headquarters, Port Harcourt, Rivers State. 2007;15-22.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/121867