Irish Journal of Environment and Earth Sciences
Irish J. Env. E. Sci.
Volume: 8; Issue: 04,
July-August, 2024
ISSN: 2383 – 6345
Impact Factor: 4.1

Advance Scholars Publication Published by International Institute of Advance Scholars Development
https://aspjournals.org/Journals/index.php/ijees

EVALUATION OF THE WATER QUALITY INDEX OF RIVER ETHIOPE IN NIGERIA FOR ITS SUITABILITY FOR DRINKING

[1]J. E. Agori, [2]J. Oba, [3]E.A. Eseha, [4]O. L. Umukoro. [5]A. A. Ugbome
[1-5]Department of Civil and Environmental Engineering, Faculty of Engineering, Oleh Campus, Delta State University, Abraka, Nigeria.
Corresponding author ***Email:*** *agorious5@gmail.com.*

Keywords: *Ethiope River; Pollution; Contaminants; Water Quality Index; Physico-chemical Parameters; WHO.*

Abstract: *Communities along the bank of River Ethiope depend on it in meeting their daily water demands. However, the river is under serious threat of contamination as a result of anthropogenic activities and natural factors, and the use of such contaminated water has resulted in lots of water borne diseases. The study was carried out to assess the suitability of water from the river for drinking by evaluating its water quality index (WQI) using the weighted arithmetic method. Water samples were collected from 6 locations along a reach of the river at Obinomba in September, 2023 and analyzed for twenty (20) physico-chemical and bacteriological water quality parameters using American Public Health Association (APHA) method of testing water and wastewater. The descriptive statistics of the water samples from these six (6) were obtained and the mean values compared to WHO permissible limits for drinking water. Ten (10) parameters were chosen and weighted according to their importance and used in evaluating the Water Quality Index (WQI) of the river. the WQI of the river varied at all locations along its course but with higher values at areas where domestic and agricultural activities are concentrated indicating more contamination in those locations. The WQI in location 1-6 were; 46.496%, 53.934%, 84.032%, 89.698%, 76.549% and 61.433% respectively. Water for drinking should be collected far downstream or upstream from the community as the contamination levels are lesser as a result of the rivers self-purification property.*

1.0 Introduction

Water is one of the most abundant natural and essential resources on the earth's surface needed by humans. It occupies more than 70% of the earth surface (Oyinloye and Jegede, 2004) occurring as both surface and groundwater. The surface water source occurring as natural streams/rivers is vital and irresistible freshwater systems for the sustenance of eco-life on earth. The rural communities in developing countries, particularly Nigeria, depend largely on rivers and other water bodies for their water consumption (Aluyi et al., 2003). Anthropogenic activities from industries and domestic households often indiscriminately discharge untreated sewage into surface water bodies. Also, runoff from farms also flow into rivers. These pollutants result in high bacterial load causing deterioration in the surface water quality, leading to epidemics that result in health hazard.

There is an inherent health implication in the consumption of contaminated water. It can lead to many water borne diseases (diarrhea, cholera, etc.) and even death when contaminated with organic and/or chemical pollutants (Bartran and Balance, 1996). Water qualities are usually not assessed before consumption by residents in most rural and urban communities. Present monitoring methods fail to account for spatial and temporal variability, limiting management's understanding of pollution hotspots and compliance with standards (Amadi et al., 2020). Communities lack current data-driven assessments of the river's suitability for direct drinking purposes on which health depends.

The River Ethiope is a key freshwater resource in Delta State, supporting domestic, agricultural and industrial needs for riparian communities in its basin (Ojakovo et al., 2015). However, rapid urbanization, industrialization and economic activities have raised concerns over deteriorating water quality affecting public health and ecosystems (Eze et al., 2018). are posing serious concerns for the river's health. The contaminants come from both point and non-point sources. This study aims to evaluate current water quality status of the river. Since River Ethiope is used for domestic and agricultural activities like bathing, laundry and cassava washing, contaminants like nutrients (nitrogen and phosphorus compounds) from bathing/washing soap and detergent effluents pose serious quality challenges as they promote excessive algal growth. Pathogens (E.coli, enterococci) from bathing and accidental sewage discharges also pose health risk for downstream users. Sediments from cassava particles or eroded soils washed into the river also increases turbidity and affects aquatic habitats. Organic matter from decomposing vegetation, human/animal waste in water increase the biochemical oxygen demand (BOD), the BOD lowers dissolved oxygen levels in surface water bodies. Also, agrochemical (pesticide/herbicide residues) from agriculture activities which flow into the river result in serious contamination.

In the past and to a lesser degree in the present, the quality of water was determined by comparing the value of a parameter in a sample of water to the acceptable range for that parameter. This approach has its short comings as it does not always provide a comprehensive view and an integrated understanding of the quality of the water (Subhasish, 2014), and the need to adopt a more accurate approach became eminent. For an accurate assessment of the river's water quality, it is important to assess its quality using approaches, like multivariate statistical methods and water quality indexes (WQI) to address this issue (Yürekli, et al., 2021).

1.1 Water Quality Index (WQI)

In this study, the water quality index was employed as a supporting tool to give clear, straight forward, and intelligible information on the Ethiope River's water quality status. The water quality index (WQI) is the total number of observations of water quality criteria that are used to make a single number that shows the overall quality of the water (Hanna, 2019). It is used to describe the quality of water for different uses, such as drinking, farming, and industry (Shahand Joshi, 2017; Ismail and Robescu, 2019). The water quality index (WQI) gives a brief indication of a large number of water quality parameters into a single term such as excellent, good, bad, very bad, and unsuitable for drinking for easy reporting to the concerned users (Hulya, 2009).

In evaluating WQI, water quality parameter concentrations are compared to established standards or guidelines for each use. Parameter values are weighted appropriately based on their relative impact on uses. Weights are summed to produce the final WQI score between 0-100. The weighted arithmetic method of evaluating WQI utilizes Equations 1 to 4.

i. First, each parameter's Quality Rating (Q_i) is determined based on its concentration:

$$Q_i = \left(\frac{C_i}{S_i}\right) \times 100 \qquad (1)$$

Where C_i is the concentration of each parameter and S_i is its standard/guideline value.

ii. The Unit Weight (W_i) is multiplied by the Quality Rating:

$$W_i = \left(\frac{K}{S_o}\right) \qquad (2)$$

Where K is the proportionality constant (usually 100) and S_o is the best score value for each parameter.

iii. The Sub-Index (SI) is calculated as the weighted average for each parameter:

$$SI = \Sigma\, (W_i x Q_i) \text{ for I =1 to n} \qquad (3)$$

Where n is the number of parameters.

iv. Finally, the overall Water Quality Index is the average of the Sub-Indices:

$$WQI = \sum \frac{SI}{n} \qquad (4)$$

From the obtained WQI, the water status is classified as follows:

- Excellent water quality (WQI of 0 -25)
- Good water quality (WQI of 26 -50)
- Poor water quality (WQI of 51-75)
- Very poor water quality (WQI of 76-100)
- Unsuitable for usage (WQI >100)

These classifications provide useful guidance on:

a) Compliance with thresholds for water uses like aquatic life, recreation, irrigation etc.

b) Prioritizing remedial efforts based on degree of impairment

c) Tracking changes in quality over time to assess impact of measures

d) Informing management decisions and standard setting

2.0 Materials and methods

2.1 Study Area

The Ethiope River originates from a community called Umuaja in Ukwani LGA in Delta State and it is located in the western part of Delta State of Nigeria. It is situated between latitude 5.53^o and 6.05^o North and longitude 5.30^o and 6.05^o East with an annual rainfall amount of 3,098mm and it covers a distance of about 96.6 kilometres (Efe & Aruegodore, 2003; Omo-Irabor and Olobaniyi, 2007). The river flows through a number of communities and then finally emptying into the Atlantic Ocean. Socio-economic activities along the river significantly affect the river quality with pH values ranging between 4.50 and 6.50 for surface and subsurface soil (Ejemeyovwi, 2006).

2.2 Materials

The materials and Method adopted in this study were in line with the APHA standard methods of testing water and wastewater (APHA, 2017), Table 1.

Irish Journal of Environment and Earth Sciences
Irish J. Env. E. Sci.
Volume: 8; Issue: 04,
July-August, 2024
ISSN: 2383 – 6345
Impact Factor: 4.1

Advance Scholars Publication Published by International Institute of Advance Scholars Development
https://aspjournals.org/Journals/index.php/ijees

Table: 1: Methods of analysis for different water quality parameters

S/N	*Parameter*	*Materials*
1	Temperature	Temperature probe
2	pH	pH meter
3	Transparency	Transparency tube
4	Turbidity	Nephelometric
5	Total dissolved solids (TDS)	Gravimetric after filtration
6	Dissolved oxygen (DO)	DO Analyzer
7	Electrical Conductivity (EC),	Conductivity meter
8	Total suspended solid (TSS)	EDTA Titrimetric
9	Biochemical Oxygen Demand (BOD)	Bottle incubation for 3-days at 27^oC
10	E. Coli	Membrane filtration (CFU)
11	Total alkalinity	Titration
12	Sodium (Na)	Flame emission photometric
13	Calcium	EDTA Titrimetric
14	Magnesium	Calculation from TH and calcium
15	Chloride	Spectrophotometer
16	Sulphate	Nephelometry
17	Nitrate	UV Spectrophotometric
18	Phosphate	Ascorbic acid spectrophotometric
19	Hydrogen bicarbonate (HCO_3)	Calculation from pH and Alkalinity
20	Lead (Pb)	Atomic Absorption Spectrophotometer (AAS)

2.3 Methods

2.3.1 Sampling locations and water samples collection

Water samples were collected in one-liter polyethylene (plastic) bottles from 6 locations along the River Ethiope at Obinomba in September 2023. The collected samples were put into a cooler with ice blocks and taken to the Chemical Engineering Laboratory of Delta State University, Oleh Campus for analysis.

2.2.2 Analysis of samples

Fifteen (20) physico-chemical and bacteriological parameters (Temperature, pH, Electrical Conductivity (EC), Transparency, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Alkalinity, (TA), Turbidity, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chloride (Cl), Sulphate (SO_4), Nitrate (NO_3), Phosphate (PO_4), Bicarbonate (HCO_3), Lead (Pb), Calcium (Ca), Magnesium (Mg), Sodium (Na) and E. Coli) were analyzed using the APHA, 2017 standard methods of testing water and waste water. However, temperature, TDS, pH, DO and EC were measured at the locations using appropriate apparatus.

2.2.3 Descriptive statistics

The results of the analyzed water samples were recorded and imported to the Microsoft Excel window. The mean, range (minimum and maximum) and standard deviation of each of the measured parameters were obtained. The mean values were compared to the WHO permissible standards.

2.2.4 Evaluation of water quality index (WQI)

From the parameters analyzed, ten (10) most important parameters were identified and assigned weights ranging from 1 to 5 with the most important assigned higher percentage. The adopted parameters, assigned weights and WHO permissible guidelines for the parameters are presented in Table 2. Assigning weights in this manner balances consideration of factors influencing aquatic/human health, biochemical/nutrient impacts, and other physio-chemical parameters when calculating an aggregate WQI

Table 2: Assigned weights, impacts and WHO permissible water quality limits

11.5	Parameters	Assigned weights	Impacts	WHO permissible limit (2011)
1	pH	3	pH levels significantly impact aquatic life.	6.5-8.5
2	BOD	1	BOD consumption stresses DO levels and shows organic waste assimilation capacity.	10.0
3	DO	5	DO concentration is critically important.	6.0
4	Temperature	3	Temperature governs DO, metabolic/growth rates of species, and other water characteristics.	25.0
5	Turbidity	2	Indicator of suspended sediment and clarity affecting aquatic life, swimming, industrial use	5.0
6	Nitrate	3	Stimulate algal blooms, eutrophication and contamination risks.	40.0
7	Phosphate	3	Phosphate is a major nutrient parameter impacting trophic state and viability of uses.	0.5
8	TDS	2	Quantifies salinity stresses on freshwater ecosystems from TDS accumulation.	500.0
9	Electrical Conductivity	1	Parallels TDS in measuring overall dissolved ion content impacts.	400.0
10	E. coli	4	Indicates potential pathogens and risks to human health.	0/100ml
		$\sum W_1 = 27$		

The weighted arithmetic method was then used to evaluate the WQI at the 6 locations using Equations 5 to 8in Microsoft Excel.

$$\text{Relative weight } (W_i) = \frac{w_i}{\sum_{i=1}^{n} w_i} \quad (5)$$

$$\text{Quality rating scale } (q_i) = \frac{c_i}{s_i} \times 100 \quad (6)$$

$$Sl_i = W_i \times q_i \quad (7)$$

$$WQI = \sum Sl_i \quad (8)$$

where;

n = Number of parameters

w_i = Weight of each parameter

Irish Journal of Environment and Earth Sciences
Irish J. Env. E. Sci.
Volume: 8; Issue: 04,
July-August, 2024
ISSN: 2383 – 6345
Impact Factor: 4.1

Advance Scholars Publication Published by International Institute of Advance Scholars Development
https://aspjournals.org/Journals/index.php/ijees

q_i = Rating based on concentration of ith parameter
c_i = Observed concentration of each parameter in each water sample in mg/l
S_i = Standard value
SI_i = Sub − index of ith parameter
W_i = Sum of mean weights

3.0 Results and Discussions

3.1 Results:

3.1.1 Water Quality of River Ethiope

The water quality parameters concentration at the six location for this study, the associated descriptive statistics and WHO permissible limits are presented in Table 3 and assigned weights, WHO permissible limit and Relative Weight (Wi) in Table 4:

Table 3: water quality parameters and their descriptive statistics at various station

Location	Temp °C	pH	EC	Trans. cm	TDS mg/l	TSS mg/l	TA mg/l	Turbi mg/l	DO mg/l	BOD mg/l	Cl mg/l	SO_4 mg/l	NO_3	PO_4 mg/l	HCO_3 mg/l	Pb mg/l	Ca mg/l	Mg mg/l	Na mg/l	E Coli cfu/ 100ml
1	24	2.11	10.2	24	0.11	34.1	90	3.48	1.8	0.6	17.6	0.25	0.32	0.002	40.0	0.06	6.4	11.6	3.9	12.0
2	25	4.51	**16.2**	25	0.11	44.3	2.0	4.20	1.6	0.2	20.4	0.52	0.72	0.01	52.7	0.05	4.12	8.6	4.5	14.1
3	25	8.20	42.9	25	4.89	45.2	19	5.82	3.6	1.2	24.6	0.50	5.16	4.92	49.8	0.09	14.2	24.0	29.4	13.4
4	25	8.50	29.7	25	7.30	53.8	20	6.90	5.5	2.2	28.2	0.60	2.13	5.05	56.7	0.08	14.2	25.0	13.2	15.6.
5	26	7.60	35.4	26	8.02	61.7	220	8.12	2.2	2.5	31.2	0.58	2.38	3.67	65.0	0.11	16.2	25.4	15.8	12.7
6	24.	4.68	11.0	24.	0.05	62.1	3.0	6.80	1.1	0.1	25.5	0.44	5.34	0.001	53.56	0.08	5.80	10.2	7.3	15.2
mean	24.83	5.93	24.23	24.83	3.41	50.20	59.0	5.89	2.63	1.13	24.6	0.48	2.68	2.28	52.96	0.08	10.2	17.5	12.4	13.48
Min	24.00	2.11	10.20	24.00	0.05	34.10	2.00	3.48	1.10	0.10	17.6	0.25	0.32	0.001	40.00	0.05	4.12	8.60	3.90	12.00
Max	26.00	8.50	42.90	26.00	8.02	62.10	220	8.12	5.50	2.50	31.2	12.6	5.34	16.96	65.00	0.11	16.2	25.4	29.4	15.20
Std. Dev	0.75	2.56	13.71	0.75	3.79	11.01	85.3	1.76	1.64	1.02	4.98	0.13	2.15	2.53	8.21	0.02	5.27	8.10	9.61	1.24
WHO limit	25	7.5	400	Not avble	500	NIL	30 - 400	5	6	10	5	250	50	5	5	0.01	75 - 200	30	40	10

3.1.2 Water Quality Index

Table 4: Assigned weights, WHO permissible limit and Relative Weight (Wi)

S/N	Parameters	Assigned weights	WHO permissible limit	Relative Weight (Wi)
1	pH	3	6.5-8.5	0.111
2	BOD	1	10	0.037
3	DO	5	6	0.185
4	Temperature	3	25	0.111
5	Turbidity	2	5	0.074
6	Nitrate	3	40	0.111
7	Phosphate	3	5	0.111
8	TDS	2	500	0.074
9	EC	1	400	0.037
10	E. coli	4	0cfu/100ml	0.148
		W_1 =27		

Irish Journal of Environment and Earth Sciences
Irish J. Env. E. Sci.
Volume: 8; Issue: 04,
July-August, 2024
ISSN: 2383 – 6345
Impact Factor: 4.1

Advance Scholars Publication Published by International Institute of Advance Scholars Development
https://aspjournals.org/Journals/index.php/ijees

Table 5: Evaluation of WQI using the weighted arithmetic method

Water Quality Parameters	pH	BOD	DO	Temp.	Turbty	NO_3	PO_3	TDS	EC	E coli	QUALITY RATING (qi) qi = (ci/si)*100									
Parameter Wt.	3	1	5	3	2	3	3	2	1	4										
WHO Standard (Si)	7.5	10	6	25	5	50	5	500	400	10										
Parameter Wt.	3	1	5	3	2	3	3	2	1	4										
SAMPLING LOCATION	MEASURED VALUES (Ci)										pH	BOD	DO	Temp.	Turb-	NO_3	PO_3	TDS	EC	E coli
1	2.11	0.6	1.8	24	3.48	0.32	0.002	0.11	10.2	12.0	28.13	6.00	30.00	96.00	69.60	0.80	0.04	0.02	2.55	170.0.
2	4.51	0.2	1.6	25	4.2	0.72	0.01	0.11	16.2	14.1	60.13	2.00	26.67	100.00	84.00	1.80	0.20	0.02	4.05	191.0
3	8.2	1.2	3.6	25	5.82	5.16	4.92	4.89	42.9	13.4	109.33	12.00	60.00	100.00	116.40	12.9	98.40	0.98	10.73	164.0
4	8.5	2.2	5.5	25	6.9	2.13	5.05	7.3	29.7	15.6.	113.33	22.00	91.67	100.00	138.00	5.33	101.00	1.46	7.43	156.0
5	7.6	2.5	2.2	26	8.12	2.38	3.67	8.02	35.4	12.7	101.33	25.00	36.67	104.00	162.40	5.95	73.40	1.60	8.85	137.0
6	4.68	0.1	1.1	24.	6.8	5.34	0.001	0.05	11	15.2	62.40	1.00	18.33	96.00	136.00	13.35	0.020	0.01	2.75	182.0

Table 5 Continues:

Location	Parameter Index (Si) = qi * Wi										WQI	Status
	pH	BOD	DO	Temp.	Turbty	NO_3	PO_3	TDS	EC	E coli		
1	3.12	0.22	5.55	7.11	5.15	0.09	0.004	0.002	0.09	25.16	46.496	Good
2	6.67	0.07	4.93	7.4	6.22	0.2	0.022	0.002	0.15	28.27	53.934	Poor
3	12.14	0.44	11.11	7.4	8.61	2.82	10.92	0.072	0.4	24.27	84.032	V. Poor
4	12.58	0.81	16.96	7.4	10.21	0.59	11.21	0.108	0.27	23.09	89.698	V. Poor
5	11.25	0.93	6.79	7.7	12.02	0.66	8.15	0.119	0.33	20.28	76.549	V. Poor
6	6.93	0.04	3.39	11.1	10.06	2.87	0.002	0.001	0.1	26.94	61.433	Poor

3.2 Discussion

Table 3 shows the concentration of twenty water quality parameters (Temperature, pH, Electrical Conductivity (EC), Transparency, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Alkalinity, (TA), Turbidity, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chloride (Cl), Sulphate (SO_4), Nitrate (NO_3), Phosphate (PO_4), Bicarbonate (HCO_3), Lead (Pb), Calcium (Ca), Magnesium (Mg), Sodium (Na) and E. Coli) and their mean values are discussed below.

3.2.1 Physicochemical and bacteriological characteristics

The average annual water temperature value was almost equal at all stations. The mean water temperature at the six stations was 24.83^{o}C and ranged from 24°C to 26°C. The water temperature was found to be within the WHO permissible limit of 25°C. The highest value has been recorded at location 5 with a value of 26°C, the minimum values were at locations 1 and 6 at24 °C, and the other three stations were between them. The difference may occur due to the sampling time during the day because all the sampling work has been done in the early morning in faraway destinations from the analysis laboratory. The finding shows that the pH values had a mean of 5.93 and ranged from 2.11 to 8.50 with standard deviation of 2.56. Which indicates that the Ethiope River samples ranged from acidic to nearly neutral and must have been as a result of natural processes such as weathering of rocks and minerals and human activities. When certain rocks containing minerals like sulphide are exposed to air and water, they can undergo chemical reactions that produce sulphuric acid. This acid can then be transported to rivers through runoff or groundwater. Human activities can significantly impact the acidity of rivers. Some common causes include: Acid Rain: Emissions of sulphur dioxide (SO_2) and nitrogen oxides (NOx) from industrial processes and fossil fuel combustion can combine with atmospheric moisture to form sulphuric acid and nitric acid, resulting in acid rain. Acid rain can fall on the land and eventually wash into rivers, making them more acidic. Industrial activities can release various acidic pollutants into rivers, such as acids, heavy metals, and other chemical compounds. Effluents from mining operations, manufacturing processes, and wastewater discharges can all contribute to river acidity. The excessive use of chemical fertilizers and pesticides can lead to nutrient runoff, which can contribute to the acidification of water bodies. Deforestation, construction, and other land-disturbing activities can accelerate erosion and increase the transport of acidic materials into rivers. According to the limitations of WHO standards, the resulting pH values are not acceptable (Oyem et al., 2015). The electrical conductivity at the six stations had a mean value of 24.23µS/cm and ranged from 10.20µS/cm to 42.90µS/cm which is far lower than the WHO standard level of 400µS/cm indicating the softness and no salinity (0 ppt) in the water. Water transparencies varied from 24.00 to 26.00cm in the six stations, with a mean value of 24.83cm. There was no significant variation of transparency in the six stations. The standard value of water transparency is 40cm. the transparency is what makes the river a tourist center as it gives a false depth. It varied from 0.05mg/l to 8.02mg/l with a mean value of 3.41mg/l and a standard deviation of 3.79mg/l and a WHO standard of 500mg/l. TDS was directly related to conductivity. The values of TDS of the present study in all stations were far below the standard level. TDS readings greatly rose as the river moved from the upstream to downstream due to extensive anthropogenic (socio economic) activities along the river's path and run-off with a high suspended matter concentration (Ogbeibu et al., 2012). It is the concentration of solid particles in the river. This varied from 34.10mg/l to 62.10mg/l with a mean value of 50.20mg/l and standard deviation of 11.01mg/l. Excessive TSS can cause impaired water clarity, habitat degradation, nutrient transportation. Turbidity ranged from 3.48 to 8.12 NTU with an average of 5.89 NTU. The WHO standard is 5 NTU. The turbidity is within WHO standard. Turbidity levels below 5 NTU are generally considered low and indicate relatively clear water. A turbidity value of 3.48 NTU falls within this low range and suggests good water clarity with minimal suspended particles. Turbidity levels between 5 and 10 NTU are considered moderate and indicate some degree of suspended particles in the water. A turbidity value of 8.12 NTU falls within this moderate range and suggests slightly increased cloudiness or haziness compared to low turbidity levels. These moderate values were observed at points of human activities. Monitoring turbidity is important for assessing water quality, evaluating treatment processes, and protecting aquatic ecosystems. It helps in identifying changes in

Irish Journal of Environment and Earth Sciences
Irish J. Env. E. Sci.
Volume: 8; Issue: 04,
July-August, 2024
ISSN: 2383 – 6345
Impact Factor: 4.1

Advance Scholars Publication Published by International Institute of Advance Scholars Development
https://aspjournals.org/Journals/index.php/ijees

suspended particle levels, tracking the effectiveness of sediment control measures, and making informed decisions regarding water management.

Total alkalinity (TA) which is a measure of the water's ability to neutralize acids and maintain a relatively stable pH level. Alkalinity is primarily caused by the presence of bicarbonate ions (HCO_3^-), carbonate ions (CO_3^{2-}), and hydroxide ions (OH^-) in water. The values ranged from 2.00 mg/l to 220mg/l suggesting a wide variation in alkalinity levels at different locations. A mean value of 59.0 mg/l while the WHO standard is in a range of 30 – 400mg/l. The variation could be attributed to anthropogenic activities at locations within the community along the river. Dissolved oxygen (DO) level of any water body is important for the survival and distribution of aquatic organisms. During the study, the DO varied from 1.10-5.50mg/l and a mean value of 2.63 mg/l. Due to different ecological condition. The low DO level was found to be not suitable for fish due to high contamination at some stations. The standard value of DO of water is 5 mg/l. The DO level below 5mg/l adversely affects aquatic lives and below 2mg/l causes death of fishes. This could be because of bad waste management, a lot of urban and rural runoff, sewage, too much application of inorganic fertilizer, and bad operation and maintenance of wastewater systems (Oluseyi et al., 2014; Shahidullah et al., 2000). Biochemical oxygen demand (BOD) is the amount of oxygen consumed by microorganisms (aerobic bacteria) in five days to break down organic compounds present in freshwater at a certain temperature over a specific period. During the study BOD varied from 0.1-2.5mg/l with a mean value of 1.13 and std. dev. of 1.02. the WHO standard is 10 mg/l. The present BOD level of the six stations of Ethiope River was far below the standard level. The water without pollution has a concentration of BOD 2mg/l or below (Kumar and Dua, 2009). As the river passed from the upstream to the downstream of the Obinomba, the average BOD values in the six monitoring stations raised considerably due to the increasing release of organic wastes. Chloride is relatively stable and does not readily degrade in the environment. Chloride ranged from 17.6 to 31.2mg/l with a mean value of 24.6mg/l and standard deviation of 4.98mg/l. WHO value is 5.0mg/l. As the river made its way downstream, the amount of pollutant burden increased, which resulted in a substantial rise in the Cl concentration. The chloride concentration in the water samples is higher than the WHO guideline value. The WHO guideline value of 5.0 mg/L for chloride in drinking water is set to ensure that the water is safe for consumption and does not pose any health risks. The mean chloride concentration of 24.6 mg/L in the water exceeded this guideline value. High chloride levels in drinking water can affect taste and may have a laxative effect, although they are generally not considered harmful to health at these concentrations (Acharya et al., 2018). Chloride levels in water can impact agricultural practices, particularly in irrigation. Some crops are sensitive to high chloride concentrations, and elevated levels can affect plant growth, yield, and overall crop health. The chloride concentration range falls within the typical range for irrigation water, but the specific crop tolerance should be considered. Elevated chloride levels in surface waters or groundwater can have environmental impacts. High chloride concentrations can be detrimental to aquatic organisms, particularly freshwater species that have low tolerance to chloride. Chloride can contribute to the salinization of soil and impact vegetation in surrounding areas. The potential sources of elevated chloride levels in the water sample include anthropogenic sources such as industrial discharges, and wastewater effluents and natural sources can include geological formations and saltwater intrusion in coastal areas. Sulphate exists naturally in surface water as SO_4. The main sources of SO_4 are discharges from waste disposal, domestic waste, and untreated sewage. The value ranged from 0.25 to 12.6 mg/l and a mean value of 0.48 mg/l, standard deviation of 0.13 mg/l with a WHO permissible limit of 250 mg/l. The mean sulphate concentration in the water sample appears to be generally within acceptable limits according to the WHO guideline. Sulphate concentrations in water can affect its taste (bitter or medicinal taste), although the taste threshold varies among individuals and odour. Sulphate itself is generally not considered harmful to human health at the concentrations typically found in drinking water. However, in some cases, high sulphate levels in water can have a laxative effect, causing gastrointestinal discomfort or diarrhea, particularly in individuals with specific sensitivities. High sulphate concentrations in water can have environmental implications, particularly in sensitive ecosystems. Sulphate can contribute to the eutrophication of water bodies and impact aquatic organisms when present in excessive amounts. Nitrate (NO_3) ranged from 0.32 to 5.34mg/l with a mean value of 2.68 mg/l and standard deviation of 2.15mg/l.Tthe WHO standard value is 50mg/l. The nitrate concentration in the water sample appears to be well below the WHO guideline value. The WHO guideline value of 50 mg/L for nitrate in drinking water is set to protect against potential health risks, particularly for infants and young children. The mean nitrate concentration of 2.68 mg/L is significantly lower than the guideline, indicating that the water sample meets the WHO standard. High nitrate levels in drinking water can lead to a condition called methemoglobinemia, or "blue baby syndrome," which affects the ability of blood to carry oxygen. The nitrate concentrations in this study are well below the guideline value, indicating that the water sample does not pose a risk for methemoglobinemia. Nitrate is an essential nutrient for plant growth and is often found in fertilizers. Elevated nitrate levels in water can result from agricultural activities, such as excessive fertilizer use or improper disposal of animal waste. High nitrate concentrations in water bodies can contribute to eutrophication, leading to algal blooms and oxygen depletion, which can harm aquatic ecosystems. However, the nitrate concentrations in the River Ethiope at the sampling locations are relatively low and are unlikely to cause significant environmental concerns. The range of PO_4 from all sampled locations is 0.001 to 16.96mg/l, mean value and standard deviation are 2.28 and 2.53mg/l respectively. The WHO permissible limit is 5mg/l. The mean phosphate concentration of 2.28 mg/L is below the guideline, but it's important to note the wide range of values and the potential for higher concentrations in some samples. High phosphate levels in drinking water can contribute to eutrophication and algal blooms, which can have ecological and health implications. Bicarbonate is a common component of the alkalinity in water and plays a role in buffering pH. It is naturally present in many water sources, including groundwater and surface water. The samples had a mean value of 52.96 and ranged from 40.00 to 65.00mg/l with a std. dev. of 8.21mg/l. the WHO standard value is 5mg/l. Elevated bicarbonate levels in water can affect the taste and hardness of water. Higher bicarbonate concentrations can contribute to water hardness and result in scale formation in pipes and appliances. The range of bicarbonate concentrations falls within the typical range for drinking water and is not considered a cause for concern in terms of health effects.

The mean value of lead at the six locations is 0.08mg/l, a range of 0.05 to 0.11mg/l and standard deviation of 0.02mg/l. The WHO value is 0.01mg/l. The mean lead concentration of 0.08 mg/L is significantly higher than the guideline, indicating that further action should be taken to mitigate lead levels in the water. The potential causes can be similar to those in drinking water but may also involve additional factors specific to the river environment. Some possible causes of elevated lead levels in a river include: industrial discharges, urban runoff, agricultural practices and historical pollution. Calcium is one of the important chemical parameters of water. During the study, Ca++ varied from 4.12 to 16.2mg/l, a mean value of 10.2mg/l and std. dev. of 5.27mg/l. while the WHO standard is 75 -200mg/l. The present result of Ca of Ethiope River is far below the permissible limit. Magnesium is an essential mineral and is commonly found in natural water sources. The mean value at the six locations is 17.5mg/l, range is 8.60mg/l to 25.4mg/l, standard deviation is 8.10mg/l and WHO recommendation is 30mg/l. The magnesium concentrations in the water samples fall within a relatively moderate range. Magnesium is general an aesthetic issue which is related to taste and odour considerations rather than health effects. It is not typically associated with significant health risks at the concentrations observed in the dataset. In fact, magnesium is considered beneficial for health and is an important dietary component. Sodium is a naturally occurring element and is commonly found in water sources. The water samples had a mean sodium value of 12.4mg/l, range of 3.90 to 29.4mg/l and standard deviation of 9.61mg/l while WHO limit is 40mg/l. The sodium concentrations in the water samples are below the WHO limit of 40 mg/L indicating that the sodium levels in the water samples are within acceptable limits. High levels of sodium in drinking water can be a concern for individuals on sodium-restricted diets or those with specific health conditions such as hypertension or kidney problems. For the general population, moderate levels of sodium in drinking water are generally considered acceptable. E Coli mean value is 13.48 cfu/100l, range is 12.00 to 15.20 cfu/100l, std. dev. is 1.24cfu/100l and the WHO limit is 10cfu/100ml indicating that the water samples may be contaminated with fecal bacteria. Elevated levels of E. coli indicate a higher likelihood of pathogens and other harmful microorganisms being present, which can pose health risks if ingested. The presence of E. coli in drinking water suggests a potential breach in the water supply system or contamination from external sources such as sewage or agricultural runoff. Since people defecate in the river and cows are seen swimming across the river that is also a possibility for the elevated E. coli concentration in the water. It is important to take immediate action to address the issue and ensure the safety of the water supply. These include disinfection, maintenance of water treatment systems, and identifying and mitigating potential sources of contamination. .

3.2.2 Water Quality Index (WQI)

The Arithmetic Water Quality Index (AWQI) method has been utilized to evaluate water purity in comparison to the norm for various uses and to shed light on how much anthropogenic influence affects the quality of the water (Fernandez et al., 2012). Table 5 shows water quality index (WQI) calculated utilizing ten physicochemical and bacteriological parameters from six stations of River Ethiope. The values for WQI fell in the range of good in Station 1 (46.496), Station 2, good (53.934) and are very bad in Stations 3, 4 and 5 (84.032, 89.698,76.549) respectively and Station 6, bad (61.433) using the Weighted Arithmetic method of Water Quality Index (WQI). The values of the WQI indicate that the river's water quality is located in the medium range at all of the stations. The Index classified the river water as good to very bad at different locations. Station1 is far upstream before the Obinomba community, the water was good. At Station 2 just on reaching the community the water was bad. In Stations 3, 4 and 5 at various locations where both domestic and agricultural activities like washing of clothes, bathing defecating, discharging household wastes, washing of cassava and sometimes cows come to drink water, the water status were very bad. These stations are also subjected to some industrial and poultry waste discharges. Then downstream away out of the community the water status improved to bad. This could be attributed to the self-purification potential of most surface water bodies. In summary, the water quality of Ethiope River is not good for drinking and if it is to be used for drinking it should be harvested far upstream ordownstream away from any community and should be treated.

4.0 Conclusions

The study assessed the water quality index of River Ethiope at the Obinomba axis using the Weighted Arithmetic Method of evaluating WQI. The water quality status varied from very poor to good. It was good upstream and downstream but very poor at areas where economic, domestic and agricultural activities are carried out. Indicating that there is variation in the quality of water along the course of the river resulting run-offs, geologic and anthropogenic. To safeguard the potability of River Ethiope, there should be adequate monitoring and control of all human activities on the river.

References

Acharya, S., Sharma, S. K., & Khandegar, V. (2018). Assessment of groundwater quality by water quality indices for irrigation and drinking in South West Delhi, India. Data Brief, 18, 2019–2028.

https://doi.org/10.1016/j.dib.2018.04.120

Aluyi, H. S. A., Atuanya, E. I., & Amoforitse, S. C. (2003). Bacteriological and physico-chemical investigations of Ethiope River, Delta State, Nigeria. African Journal of Applied Zoology & Environmental Biology, 5, 29–36.

Amadi, A. N., Iheakananwa, C. O., Onyema, C. C., Onwuamna, C. C., Nwankwoala, H. O., & Ejikeme, P. M. (2020). Assessment of spatial and temporal variations in water quality of River Benue using multivariate statistical techniques. Environmental Monitoring and Assessment, 192(9), 1–20. https://doi.org/10.1007/s10661-020-08508-1

American Public Health Association (APHA). (2017). Standard methods for examination of water and wastewater (23rd ed.). Washington, D.C.: American Public Health Association.

Bartram, J., & Balance, R. (1996). Water quality monitoring: A practical guide to the design and implementation of freshwater quality studies and monitoring programmes. E and F. N. Spoon.

Efe, S. I., & Aruegodore, P. (2003). Aspect of microclimates in Nigerian rural environment: The Abraka experience. Journal of Research and Production, 2(3), 48–57.

Ejemeyovwi, D. O. (2006). Physico-chemical characteristics, classification, and mapping of soils in Abraka. In A. Akinbode & B. A. Ugbomeh (Eds.), Abraka region: Occasional publications (pp. 48–66). Department of Geography and Regional Planning, Delta State University.

Eze, J. I., Ejiofor, A. O., Ezeigbo, C. N., Nwankwoala, H. O., Nwoke, L. U. C., & Ezeanyim, B. U. (2018). Assessment of water quality index and suitability of major rivers in Anambra State, Nigeria. Open Journal of Modern Hydrology, 8(2), 53–79. https://doi.org/10.4236/ojmh.2018.82005

Fernandez, N., Ramirez, A., & Solano, F. (2012). Physico-chemical water quality indices – A comparative review. Bistua: Revista de la Faculty de Ciencias Basicas, 2(1), 19–30.

Hanna, N. S., Shekha, Y. A., & Ali, L. A.-Q. (2019). Water quality assessment of Rawanduz River and Gali Ali Beg stream by applying CCME WQI with a survey of aquatic insects (Ephemeroptera). Iraqi Journal of Science, 2550–2560.

Hulya, B. (2009). Utilization of the water quality index method as a classification tool. Environmental Monitoring and Assessment, 167, 115–124.

Ismail, A. H., & Robescu, D. (2019). Assessment of water quality of the Danube River using water quality indices technique. Environmental Engineering and Management Journal, 18, 1727–1737.

Lateef, Z., Al-Madhhachi, A., & Sachit, D. (2020). Evaluation of water quality parameters in Shatt Al-Arab, Southern Iraq, using spatial analysis. Hydrology, 79, 1–33.

Noor, A. H., Alharbawee, I., Ahmed, J. M., & Wesam, M. (2023). Water quality index of the Tigris River in the central region of Iraq. Journal of Techniques, 5(4), 141–147.

Ogbeibu, A. E., Chukwurah, N. A., & Oboh, I. P. (2012). Effects of an open waste dumpsite on groundwater quality in Ekurede-Urhobo, Warri, Delta State, Nigeria. Tropical Freshwater Biology, 21(2), 81–98.

Ojakovo, A. O. A., Nwankwoala, H. O., & Iyke, O. E. (2015). Evaluation of the water quality index of River Ethiope using multivariate statistical techniques. Applied Water Science, 5(3), 247–255. https://doi.org/10.1007/s13201-015-0250-2

Oluseyi, T., Adetunde, O., & Amadi, E. (2014). Impact assessment of dumpsites on the quality of nearby soil and underground water: A case study of an abandoned and a functional dumpsite in Lagos, Nigeria. International Journal of Science, Environment and Technology, 3(3), 1004–1015.

Omo-Irabor, O. O., & Olobaniyi, S. B. (2007). Investigation of the hydrological quality of Ethiope River watershed, Southern Nigeria. Journal of Applied Science and Environmental Management, 1(2), 13–19.

Oyem, H. H., Oyem, I. M., & Usese, A. I. (2015). Iron, manganese, cadmium, chromium, zinc, and arsenic groundwater contents of Agbor and Owa communities of Nigeria. SpringerPlus, 4, 104–114.

Oyinloye, A. O., & Jegede, G. O. (2004). Geophysical survey, geochemical and microbiological investigation of groundwater in Ado–Ekiti North, South Western Nigeria. Global Journal of Geological Sciences, 2(2), 235–242.

Shah, K. A., & Joshi, G. S. (2017). Evaluation of water quality index for River Sabarmati, Gujarat, India. Applied Water Science, 7, 1349–1358.

Shahidullah, S. M., Hakim, M. A., Alam, M. S., & Shamsuddoha, A. T. M. (2000). Assessment of groundwater quality in a selected area of Bangladesh. Pakistan Journal of Biological Sciences, 3, 246–249.

Subhasish, D. (2014). Fluvial hydrodynamics: Hydrodynamic and sediment transport phenomena-GeoPlanet: Earth and planetary sciences. New Delhi, India, 158–162.

Irish Journal of Environment and Earth Sciences
Irish J. Env. E. Sci.
Volume: 8; Issue: 04,
July-August, 2024
ISSN: 2383 – 6345
Impact Factor: 4.1

Advance Scholars Publication Published by International Institute of Advance Scholars Development
https://aspjournals.org/Journals/index.php/ijees

World Health Organization (WHO). (2011). Guidelines for drinking-water quality (4th ed.). WHO Chronicle, 38, 104–108.

Yürekli, K., Erdoğan, M., Ismail, A. H., & Shareef, M. A. (2021). How far can hydrochemical characteristics of surface water meet drinking and irrigation criteria: A pragmatic study for the Euphrates River basin, Turkey. Sustainable Water Resources Management, 7, 1–11.