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WATER QUALITY INDEX: A VITAL TOOL IN ASSESSING WATER QUALITY OF A RIVER

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Abstract -One of the renewable resources needed for food production, economic growth, the maintenance of all living forms, and overall well-being is water. In this study, Oji River is evaluated as a vital water resource in Enugu State, supporting various human activities, including drinking water supply, irrigation, and fishing. However, the river's water quality is under threat from anthropogenic activities, such as industrial effluents, agricultural runoff, and domestic waste. The study assesses the variations in water quality of the river using Water Quality Index (WQI) method. Water samples were collected from sampling points along Oji River during both rainy and dry seasons and analyzed for physical and chemical parameters, including pH, temperature, turbidity, total dissolved solids, electrical conductivity, and bacterial contaminants. The WQI was calculated using the weighted arithmetic index method, and the results showed significant variations in water quality up to 17.48 %. The summary of the calculated values for WQI shows a rise during the dry season, which ranged from 17.18 to 45.17, with an average of 31.89, which was significantly below 100 and could be categorized as poor. The highest WQI value of 45.17 was recorded during the dry season, although the river is unsafe for use in both seasons of the year, according to the comparison of the water quality index values. This value showed that the water ranked 'very bad' with a WQI value less than 100 %. The water quality was generally poor with high levels of total dissolved solids, heavy metals, and nitrates. Depending on the intended mode of use, this grade denotes serious pollution and necessitates a large degree of remediation. This study highlights the importance of assessments of water quality in riversthat are vulnerable to anthropogenic impacts. The WQI method proved to be a useful tool for evaluating water quality and identifying areas that require immediate attention. The findings of this study can inform policy decisions and strategies for managing a River's water quality and protecting its ecosystem.

Keywords:Water Quality Index (WQI), Water Pollution, Oji River, Environmental Monitoring

1. Introduction

The rapid population growth and accelerated pace of modernization have resulted in a substantial increase in the demand for freshwater during the past few decades (Ahmad et al., 2021). Water quality has declined in many regions of the world as a result of anthropogenic activities linked to widespread urbanization, agricultural practices, industrialization, and population growth (Akhtar et al., 2021; Giri 2021). Human actions are the leading causes of river pollution (Lin et al., 2022). Industrial effluents, containing toxic chemicals and heavy metals, are discharged directly into rivers, harming aquatic life (Gavhaneet al., 2021). Agricultural runoff, rich in fertilizers and pesticides, contaminates rivers, promoting algae blooms and depleting oxygen (Gavhaneet al., 2021). Domestic sewage, often untreated, releases pathogens and nutrients, posing health risks to humans and wildlife.Deficient water resources have also made it more difficult to improve water quality and reduce pollution (Zhang and Oki 2023). Natural factors, such as soil erosion and sedimentation, contribute to river pollution (Akhtar et al. 2021). Climate change intensifies flooding, altering water cycles and increasing pollutant transport, therefore, protecting river water quality is extremely urgent because of serious water pollution and global scarcity of water resources (Akhtar et al. 2021).

Millions of tonnes of heavy metals, solvents, toxic sludge, and other pollutants are dumped into water bodies annually by industries, while 80 percent of municipal wastewater worldwide is released into water bodies untreated (United Nations World Water Assessment Programme, WWAP, 2017). River pollution has severe consequences, which range from harm to aquatic life and ecosystems. Many of the aquatic animals that depend on a clean aquatic environment to survive will become endangered species as a result of the polluted river (Sononeet al., 2022). River pollution has direct, severe impacts on human health, ranging from mild to life-threatening conditions such as waterborne diseases like cholera, typhoid, diarrhea, dysentery. Respiratory issues like asthma, bronchitis, and lung damage have also been reported (Krismanuel and Hairunisa 2024). Some cases of cancer as a result of increased risk from chemical exposure, like heavy metals and pesticides, have also been reported (Wallace and Djordjevic 2020). River pollution has also been significantly correlated with economic implications, affecting various sectors and communities. In fisheries and aquaculture, loss of fish populations as a result of polluted rivers has negative influences on the productivity, as some of the people engaging in this business have lost their means of livelihood (Eriegha and Sam 2020). Also linked with river pollution is crop yields as river pollution has been attributed to a decline in crop yield, as reported by Liliane and Charles (2020). Many industries now need more finances to treat the water being used in production as a result of polluted water. This has led to a reduction in productivity as reported by Mokarramet al. (2020).

Mokarram et al. (2022) in their study stated that a nearby petrochemical sector is one of the main causes of contamination in Iran's Kor River. Ena et al. (2019) found that the main sources of pollution in Malaysian river waterways include sewage facilities, pig pens, manufacturing firms, agro-based enterprises, and wet markets. Agbabiaka and Oyeyiola (2012) conducted a field study on microbiological evaluations of soil sediments in the Foma River, Ita-Nmo, Ilorin, Nigeria, and found that dolomite mining and soil erosion were the causes of surface water bodies' turbidity and BOD. According to Onyegeme and Ogunka's (2017) field study on the physicochemical characteristics of the water quality of the Imeh, Edegelem, and Chokocho communities along the Otamiri-Oche River in the Etche ethnic nationality of Rivers State, Nigeria, a significant amount of oxygen-demanding wastes from domestic sources were found to be causing abnormalities in parameters like pH, total dissolved solids (TDS), dissolved oxygen (DO), BOD, and chemical oxygen demand (COD), alkalinity, hardness, chloride, and nitrate-nitrite.According to studies by Victor(2020) on the physico-chemical characteristics and heavy metal concentrations of the Osun River, there is a significant level of pollution with Pb, Cd, Ni, Cr, Zn, cyanide ions, and ammonia. These studies suggest that activities around a river are possible sources of pollution and deterioration of the river's quality.

Despite the importance of Oji River as a freshwater source, it's water quality remains largely unassessed, particularly with seasonal variations, posing significant risks to human health and aquatic life. The lack of comprehensive and seasonal water quality assessment of Oji River using Weighted Water Quality Index (WWQI) hinders effective management and conservation of this vital resource as reported by (Ugochukwu and Onuora 2019). The current state of the river is unclear due to inadequate seasonal monitoring, which may lead to ineffective management decisions and compromised ecosystem health. Therefore, this study assesses the seasonal variations in water quality of Oji River in terms of TDS, TSS, Turbidity, Nitrates, Nitrites, heavy metals, using a weighted water quality index. It identifies parameters that contribute to water quality deterioration and possible remediation strategies for sustainable water quality and environmental protection.

2. Methodology

Oji River is located in Enugu State, Southeastern Nigeria, at Latitude: 6.45°N - 6.65°N, Longitude: 7.35°E - 7.55°E. The river quality has been a source of environmental concerns as it is exposed to the pollution from both agricultural runoff and industrial activities, deforestation and land degradation, and flooding during heavy rainfall events (Ugochukwu and Onuora 2019). Oji River is bounded and passes through the following towns: Oji River Town, Enugu Ezike, Achi, Awgu, and Nenwe. The river covers three Local Government Areas of Enugu State: Oji River LGA, Awgu LGA, and Aninri LGA. Oji River is an important source of domestic and agricultural uses in Enugu and its environs.

Two distinct sample locations were used for analysis in this paper to represent both dry and wet seasons, covering May and December 2024. Surface water samples were collected in triplicate from each sampling point for each sampling period in both dry and wet seasons along the river course. For sampling location A, the three samples were labeled A1, A2, and A3,and location B was labeled BI, B2, and B3. At each sampling location, water samples were collected in plastic bottles specially prepared for sampling. The sample bottles were labeled according to sampling locations. All samples were preserved at 4 ^{o}C and transported to the laboratory for analysis.

Physico-chemical analysis was conducted using established analytical procedures according to APHA (1992). Color, pH, Total Hardness, Calcium, Magnesium, Total Alkalinity, Electrical Conductivity, Phosphate, Nitrates, and Manganese are the significant metrics that this study is interested in. According to Tyagiet al. (2013), these are significant factors in assessing the level of pollution and indicators of a river body's ability to purify itself. Standard statistical techniques were used to evaluate the data obtained from laboratory analyses (Chapman 1992).

In calculating the WQI, the weighted arithmetic index method was applied to assess water suitability for drinking purposes. In this method, water quality rating scale, relative weight, and overall WQI were calculated from equation 1

$$q_i = \left({C_i - C_{id}} \middle/ {S_i - C_{id}} \right) \times 100 \quad 1$$

where q_i = quality rating scale

C_i= concentration of I_{th} parameter

S_i= standard value of I_{th} parameter

C_{id} = ideal concentration of I_{th} parameter

Unit weight was then derived as;

$$w_i = {k} / {S_i}. \quad 2$$

Where the standard value of the I_{th} parameter is inversely proportional to the unit weight.

K is a constant value calculated as: $k = \frac{1}{\sum_i^n \frac{1}{S_i}}$,

where n represents the number of parameters considered for analysis.

Overall WQI is then calculated as

$$WQI = {\sum_{i=1}^{n} q_i w_i} / {\sum_{i=1}^{n} w_i}$$

3. **Results and Discussions**

The results for physiochemical and microbial parameters such as pH, Electrical conductivity, total alkalinity, total hardness, calcium, magnesium, chlorine, COD, BOD, phosphate, nitrates, manganese, iron, and organic matter are presented in Tables 1 and 2.

Table 1: Water Quality Analysis during Wet Season

S/ID	°C	pH	EC µS/cm	TA mg/l	TH mg/l	Ca mg/l	Mg mg/l	Cl mg/l	COD mg/l	BOD mg/l	NO3 mg/l	Fe mg/l	Mn mg/l	PO_4 mg/l
A1	27	6.70	7.30	34	6.94	10.3	12.1	15.9	3.8	1.01	0.4	0.18	0.5	0.44
A2	27	6.84	7.54	32	7.21	11.4	10.8	16.8	4.5	0.51	0.3	0.20	0.48	0.36
A3	26	6.79	8.63	32	6.50	9.8	14.3	19.0	3.1	0.98	0.4	0.25	0.67	0.28
B1	26	5.60	9.95	30	7.8	11.5	1.30	2.5	7.9	0.84	0.7	0.5	0.7	0.32
B2	27	5.21	10.31	44	9.3	15.1	3.81	7.9	6.3	0.5	0.9	0.72	0.9	0.26
B3	27	5.73	12.04	36	12.1	18.8	5.4	5.4	11.4	1.08	0.95	1.01	0.8	0.30

From Table 1, pH values of the samples collected range from 5.21 to 6.84, which is more acidic in nature. The highest electrical conductivity recorded during this period was 12.04µS/cm and far below the permissible limit of 400 µS/cm. The lesser value of electrical conductivity recorded could be attributed to reduced concentration of pollutants washed into the river by runoff, since river flows in the rainy season, and contaminants are diluted by flowing water. The influence of precipitation is being felt in the results as the values of a few parameters investigated experienced an increase in concentration, particularly chlorine, phosphates, nitrates, and COD. These are attributed to diluted pollutants in the river due to the rainy period.

Table.2: Water Quality Analysis during Dry Season

S/ID	C	Ph	EC µS/cm	TA mg/l	TH mg/l	Ca mg/l	Mg mg/l	Cl mg/l	COD mg/l	BOD mg/l	NO3 mg/l	Fe mg/l	Mn mg/l	$P0_4$ Mg/l
A1	31	7.2	106	41	44.6	29.0	4.01	13.7	3.0	1.51	0.35	1.3	0.3	0.19
A2	30	6.8	129	56	49.3	35.7	4.31	14.1	3.5	1.02	0.45	1.5	0.28	0.18
A3	31	6.7	145	50	46.3	33.8	3.98	16.8	2.9	1.30	0.35	1.2	0.47	0.15
B 1	33	5.9	61	46	43.7	28.1	10.71	3.5	5.3	1.8	0.8	1.0	0.5	0.13
B 2	32	6.5	78	42	53.0	37.5	16.8	5.7	4.7	1.56	0.95	1.43	0.7	0.12
B 3	31	6.2	69	40	51.8	34.6	13.9	3.4	8.9	2.34	1.3	1.31	0.6	0.16

From Table 2, temperature varied from 30 to 33 °C for the dry unlike the wet season, the observed slight difference in the two seasons was due to the fact that temperature tends to be higher in the dry season as reported by NIMET (2009). This could be due to weather variations occasioned by the distinctiveness of the two main seasons in Nigeria.The pH values of the samples range from 5.9 to 7.2. The highest electrical conductivity EC, recorded during this period, was 145 µS/cm, which is far below the permissible. The same goes for all other parameters in the collected river water samples, with exception to heavy metals which crossed their permissible limit.

The reported low values are consistent with the findings of Ololade and Ajayi (2009), however, in contrast to the wet season, BOD levels during the dry season ranged from 1.02 to 2.34 mg/L. However, whereas the results were consistent with those of Akinbile et al. (2018), which suggested that the water was deemed polluted, the BOD values were within the acceptable ranges set by the WHO, FAO, and NSDWQ.

In terms of the majority of the physicochemical parameters examined during both seasons, including temperature, pH, EC, total alkalinity, total hardness, calcium, magnesium, chlorine, and nitrate, the result demonstrates that the quality of the river water under study was satisfactory. Iron and manganese levels, pH, phosphate, chemical and biochemical oxygen demands, and other indicators, however, did not meet WHO acceptable limits. Furthermore, there was a notable difference between the river's physicochemical parameters throughout the dry and wet seasons. Chloride in water can come from a variety of sources, such as the weathering of different rocks, surface runoff from agricultural areas that rely on inorganic fertilizers, irrigation outflow, animal feed, and more. The chloride concentration during the wet season varied between 2.5 and 19.0 mg/L and 3.4 and 16.8 mg/L during the dry season. The chlorine levels found in river water were considerably under the 250 mg/L allowable limit.

Phosphate levels in a river must not be higher than 0.1 mg/L. Exceeding certain quantities of phosphates can be quite dangerous. According to this study, the greatest phosphate levels for the dry and wet seasons are, respectively, 0.19 and 0.44 mg/L respectively, surpassing the limit (0.1 mg/L), which could be attributed to excessive human and animal waste, household wastewater,industrial effluents, and fertilizer runoff. Alkalinity levels in water samples increased from 40 to 56 mg/L during the dry season and from 30 to 44 mg/L during the wet season due to the presence of carbonate, bicarbonate, and hydroxide ions but much below 200 mg/L permissible limit by WHO. When heavy metals like iron (Fe) were tested for in the river, they were found to be present in trace amounts during the wet season but not during the dry season. Conversely, manganese (Mn) was present in both seasons in significant amounts, with the wet season having a somewhat higher concentration.

Calculation of Water Quality Index of Water Sample

The WQI for the sampling periodsare presented in Tables 3 to 6 representing different values of WQI for wet and dry seasons represented as May and December, 2024, for sampling points A and B.

Table 3: WQI for Wet Season at Sampling Point A

S/ID	pH	EC S/cm	A mg/l	TH mg/l	Ca mg/l	Mg mg/l	Cl mg/l	COD mg/l	BOD mg/l	NO3 mg/l	Fe mg/l	Mn mg/l	PO_4 mg/l	Σ
A1	6.70	7.30	34	6.94	10.3	12.1	15.9	3.8	1.01	0.4	0.18	0.5	0.44	
A2	6.84	7.54	32	7.21	11.4	10.8	16.8	4.5	0.51	0.3	0.20	0.48	0.36	
A3	6.79	8.63	32	6.50	9.8	14.3	19.0	3.1	0.98	0.4	0.25	0.67	0.28	
Obs.V.	**6.78**	**7.82**	**32.67**	**6.88**	**10.5**	**12.4**	**17.23**	**2.5**	**0.83**	**0.37**	**0.21**	**0.55**	**0.36**	
St. V.	7.4	400	200	500	200	150	250	7.5	5	50	0.3	0.5	0.1	
1/S.V	0.135	0.003	0.005	0.002	0.005	0.007	0.004	0.13	0.2	0.33	3.3	2.0	10	**15.847**
K	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	
Wi	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.013	0.001	0.210	0.126	**0.631**	**1.000**
Qi	-55	-4230	-1758	25	-1965	-773	-285	-317	-157	-14	16.67	53.5	25	
WiQi	-0.47	-0.67	-0.55	15.78	-0.61	-0.32	-0.07	-2.66	-1.98	0.018	3.51	6.75	15.78	**17.784**

$$WQI = \sum_{i=1}^{n} q_i w_i \Big/ \sum_{i=1}^{n} w_i .$$

$$WQI = 17.484 / 1.00$$

WQI = 17.484

Table 4: WQI for Wet Season at Sampling Point B

S/ID	pH	EC μS/cm	TA mg/l	TH mg/l	Ca mg/l	Mg mg/l	Cl mg/l	COD mg/l	BOD mg/l	NO3 mg/l	Fe mg/l	Mn mg/l	PO4 mg/l	Σ
B1	5.60	9.95	30	7.8	11.5	1.30	2.5	7.9	0.84	0.7	0.5	0.7	0.32	
B2	5.21	10.31	44	9.3	15.1	3.81	7.9	6.3	0.5	0.9	0.72	0.9	0.26	
B3	5.73	12.04	36	12.1	18.8	5.4	5.4	11.4	1.08	0.95	1.01	0.8	0.30	
Obs.V.	**5.51**	**10.77**	**36.67**	**9.73**	**15.13**	**3.50**	**5.27**	**8.53**	**0.81**	**0.85**	**0.74**	**0.8**	**0.33**	**15.847**
St. V.	7.4	400	200	500	200	150	250	7.5	5	50	0.3	0.5	0.1	
1/S.V	0.135	0.003	0.005	0.002	0.005	0.007	0.004	0.13	0.2	0.33	3.3	2.0	**10**	
K	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	
Wi	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.013	0.001	0.210	0.126	**0.631**	**1.000**
Qi	-372.5	-3935	-1358	-9047	-1502	-1663	-1481	286.33	-159	34	69.6667	78.5	22	
WiQi	-3.176	-0.620	-0.428	-1.141	-0.473	-0.699	-0.374	2.409	-2.007	0.0429	14.654	9.907258	13.882	**31.974**

$$\mathbf{WQI = \sum_{i=1}^{n} q_i w_i \Big/ \sum_{i=1}^{n} w_i .}$$

$$WQI = {}^{31.974}/_{1.00}$$

WQI = 31.97

Table 5: WQI for Dry Season at Sampling Point A

S/ID	pH	EC µS/cm	TA mg/l	TH mg/l	Ca mg/l	Mg mg/l	Cl mg/l	COD mg/l	BOD mg/l	NO3 mg/l	Fe mg/l	Mn mg/l	PO_4 mg/l	Σ
C1	7.2	106	41	44.6	29.0	4.01	13.7	3.0	1.51	0.35	1.3	0.3	0.19	
C2	6.8	129	56	49.3	35.7	4.31	14.1	3.5	1.02	0.45	1.5	0.28	0.18	
C3	6.7	145	50	46.3	33.8	3.98	16.8	2.9	1.30	0.35	1.2	0.47	0.15	
Obs.V.	**6.9**	**126.67**	**49**	**46.73**	**32.83**	**4.1**	**14.87**	**3.13**	**1.28**	**0.38**	**2.0**	**0.35**	**0.17**	
St. V.	7.4	400	200	200	75	50	155	7.5	8	10	0.3	0.5	0.1	
1/S.V	0.135	0.003	0.005	0.005	0.01	0.02	0.01	0.13	0.2	0.33	3.3	2.0	10	**15.847**
K	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	
W_i	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.012	0.001	0.210	0.126	0.000	**1.000**
Q_i	-25	7654	-125	-5347	268	-1603	-521	-253	-112	-13	195.6	33.5	-5347	
$W_i Q_i$	-0.213	1.207	-0.039	-0.674	0.085	-0.674	-0.131	-2.134	-1.413	-0.016	41.157	4.227	-0.674	**45.166**

$$WQI = \sum_{i=1}^{n} q_i w_i \Big/ \sum_{i=1}^{n} w_i .$$

$$WQI = {}^{45.166}/_{1.00}$$

WQI = 45.17

Table 6: WQI for Dry Season at Sampling Point B

S/ID	pH	EC µS/cm	TA mg/l	TH mg/l	Ca mg/l	Mg mg/l	Cl mg/l	COD mg/l	BOD mg/l	NO3 mg/l	Mn mg/l	Fe mg/l	PO_4 mg/l	Σ
B1	5.9	61	46	43.7	28.1	10.71	3.5	5.3	1.8	0.8	0.5	1.0	0.13	
B2	6.5	78	42	53.0	37.5	16.8	5.7	4.7	1.56	0.95	0.7	1.43	0.12	
B3	6.2	69	40	51.8	34.6	13.9	3.4	8.9	2.34	1.3	0.6	1.31	0.16	
Obs.V.	**6.2**	**69.33**	**42.67**	**49.5**	**33.4**	**41.41**	**4.2**	**6.3**	**1.9**	**1.02**	**0.6**	**1.25**	**0.14**	
St. V.	7.4	400	200	200	75	50	155	7.5	8	10	0.5	0.3	0.1	
1/S.V	0.135	0.003	0.005	0.005	0.01	0.02	0.01	0.13	0.2	0.33	2.0	3.3	10	**15.847**
K	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	**0.063**	
W_i	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.013	0.001	0.126	0.210	0.631	**1.000**
Q_i	-200	1920	-758	-5070	325	2127	-1588	63.333	-50	51	58.5	120.667	3	
$W_i Q_i$	-1.705	0.302	-0.239	-0.639	0.103	0.895	-0.400	0.533	-0.631	0.064	7.383	25.382	1.8931	**32.939**

$$WQI = \sum_{i=1}^{n} q_i w_i \Big/ \sum_{i=1}^{n} w_i .$$

$$WQI = {}^{32.939}/_{1.00}$$

WQI =32.94

Table 7: Summary of WQI Values for the sampling periods and locations

Month	Point	WQI	Average WQI	Remark
May, 2024	A	17.48		
	B	31.97	24.73	Bad
December, 2024	A	45.17		
	B	32.94	39.05	Bad

The summary of the calculated values for WQI in table 7 shows a rise during the dry season which ranged from 17.18 to 45.17, with an average of 31.89, which was significantly below 100 and could be categorized as poor. The highest WQI value of 45.17 wasrecorded during the dry season, and the lowest was 17.48 recorded during the rainy season. Despite these seasonal variations, the river is unsafe for use in both seasons of the year, according to the comparison of the water quality index values.

4. Conclusion and Recommendations

The use of inorganic fertilizer along farmlands very close to riverbanks are primary sources of pollutants like phosphate and nitrate, among many others. However, the study found that the discharge of untreated trash from nearby enterprises and municipalities into the watershed had an unfavorable effect on the physicochemical features of the river upstream. This result indicates that the Oji River within the studied locations cannot serve as a source of drinking water unless it is treated before consumption. For rural communities that depend on the body of water for recreational and household uses, this presents a major health danger. For most of the physicochemical characteristics examined in both seasons, the river water quality was deemed adequate. However, the pH, phosphates chemical oxygen demand, biochemical oxygen demand, and iron and manganese content of the samples did not meet WHO permitted levels. Furthermore, as the concentration of additional contaminants rose during the dry season, there was a notable difference in the stream's physicochemical characteristics between the wet and dry seasons. This suggests that during the dry season, the river was more contaminated. Although the river has been found to be suitable for both industrial and agricultural usage, it still needs to be adequately treated before being used for drinking and other household purposes. To prevent anthropogenic activities that could further make the Oji River unsuitable, it requires a certain amount of protection and preventative management strategies, such as reducing pollution through proper waste disposal and wastewater treatment, promoting sustainable agriculture, protecting riverbanks, and implementing environmental regulations.

References

Agbabiaka, T. O., &Oyeyiola, G. P (2012). Microbial and Physiochemical Assessment of Foma River, Ita- Nno, Ilorin, Nigeria: An important source of domestic water in Ilorin metropolis. International Journal ofPlant, Animal and Environmental Science, 2(1): 209-218.

Ahmad, A., Abdullah, S. R. S., Hasan, H. A., Othman, A. R., & Ismail, N. I. (2021). Aquaculture industry: Supply and demand, best practices, effluent, and its current issues and treatment technology. Journal of Environmental Management, 287, 112271.

Akhtar, N., SyakirIshak, M. I., Bhawani, S. A., & Umar, K. (2021). Various natural and anthropogenic factors responsible for water quality degradation: A review. Water, 13(19),

Akinbile, C. O., &Omoniyi, O. (2018). Quality assessment and classification of Ogbese River using water quality index (WQI) tool. Sustainable Water Resources Management, 4, 1023-1030.

American Public Health Association (APHA), (1992). Standard Methods for Examination of Water and Wastewater, 18th ed. APHA, Washington, DC.

Chakraborty, S. K., & Chakraborty, S. K. (2021). River pollution and perturbation: Perspectives and processes. Riverine Ecology Volume 2: Biodiversity Conservation, Conflicts and Resolution, 443-530.

Chapman, D. (1992). Water quality assessments. A guide to the use of biota, sediments, and water in environmental monitoring. UNESCO/WHO/ENEP

Ena, A. W. C., Xiang, C. C., AbdAzizc, M. S., &Markomd, N. (2019). Water Pollution Sources and Solutions–From Global to Local. In Conference Proceedings of International Seminar on Global Issues (ISGI 2019) (p. 141).

Eriegha, O. J., & Sam, K. (2020). Characterization of crude oil impacts and loss of livelihood in the Niger Delta, Nigeria: a fisheries perspective. Int J Interdiscip Res, 1, 255-273.

Gavhane, S. K., Sapkale, J. B., Susware, N. K., &Sapkale, S. J. (2021). Impact of heavy metals in riverine and estuarine environment: A review. Res. J. Chem. Environ, 25(5), 226-233.

Giri, S. (2021). Water quality prospective in Twenty First Century: Status of water quality in major river basins, contemporary strategies and impediments: A review. Environmental Pollution, 271, 116332.

Krismanuel, H., &Hairunisa, N. (2024). The Effects of Air Pollution on Respiratory Problems: A Literature Review. Poltekita: JurnalIlmuKesehatan, 18(1), 1-15.

Liliane, T. N., & Charles, M. S. (2020). Factors affecting yield of crops. Agronomy-climate change & food security, 9.

Lin, L., Yang, H., & Xu, X. (2022). Effects of water pollution on human health and disease heterogeneity: a review. Frontiers in environmental science, 10, 880246.

Mokarram, M., Pourghasemi, H. R., Huang, K., & Zhang, H. (2022). Investigation of water quality and its spatial distribution in the Kor River basin, Fars province, Iran. Environmental Research, 204, 112294.

Mokarram, M., Saber, A., &Sheykhi, V. (2020). Effects of heavy metal contamination on river water quality due to release of industrial effluents. Journal of Cleaner Production, 277, 123380.

Onyegeme-Okerenta, B. M., &Ogunka, M. O. (2017). Physicochemical Properties of Water Quality of Imeh, Edegelem and Chokocho Communities located along Otamiri-Oche River in Etche Ethnic Nationality of Rivers State, Nigeria. Journal of Applied Science andEnvironmental Management, 20(1):113-119.

Sonone, S. S., Jadhav, S., Sankhla, M. S., & Kumar, R. (2020). Water contamination by heavy metals and their toxic effect on aquaculture and human health through food Chain. Lett. Appl. NanoBioScience, 10(2), 2148-2166.

Tyagi, S., Sharma, B., Singh, P., &Dobhal, R. (2013). Water quality assessment in terms of water quality index. American Journal of water resources, 1(3), 34-38.

Ugochukwu, U. C., Onuorah, A. L., &Onuora, O. H. (2019). Eutrophication potential of nutrients in Oji River of Enugu, Nigeria. J Environ Stud, 4(1), 4.

United Nations World Water Assessment Programme (WWAP)**. (**2017). The United Nations World Water Development Report 2017: Wastewater, the untapped resource. Paris, United Nations Educational, Scientific and Cultural Organization.

Victor, E. O. (2020). Seasonal Variation of Physico-Chemical Parameters and Heavy Metals in Water Samples from Gold Mine Reservoir, Osun State, Nigeria. East African Scholars Journal of Education, Humanities and Literature, 3(3), 91-95

Wallace, D. R., &Djordjevic, A. B. (2020). Heavy metal and pesticide exposure: A mixture of potential toxicity and carcinogenicity. Current Opinion in Toxicology, 19, 72-79.

Zhang, C. Y., & Oki, T. (2023). Water pricing reform for sustainable water resources management in China’s agricultural sector. Agricultural Water Management, 275, 108045.