DETERMINATION OF THE WATER QUALITY INDEX (WQI) OF OKULU RIVER IN ELEME, RIVERS STATE, NIGERIA.

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Abstract

The aim of the research was to evaluate the physicochemical and microbiological characteristics of Okulu River in Eleme, Rivers State, in order to establish the status of the water body as a result of the numerous industrial activities that take place in the area. Five sampling stations were selected along the river stretch and sampling made for six months. Water samples were collected for physicochemical and microbiological analyses using titrimetric, spectrophotometric and microbiological techniques. Sediment samples were also collected for physicochemical and heavy metal level analyses. The mean result of the physicochemical characteristics in water ranged as follows: Temperature (29.03±1.40 ^{o}C– 29.82±1.68^{o}C); pH (6.25±0.48 – 6.73±0.44); Electrical conductivity (3070.0±491.67µs/cm - 5187.50±1071.23µs/cm); Salinity (1.57±0.97ppt – 2.55±1.26ppt); Turbidity (9.68±5.91NTU – 19.87±9.68NTU) and Total Dissolved Solids (1540.83±242.69mg/l – 2603.00±539.60mg/l); on the other hand, levels of Cadmium, Nickel and lead ions were below detection limits while chromium levels recorded ranged between 0.015±0.01mg/l and 0.01.8±0.01mg/l in some stations. Microbiological study of the water showed that mean level of Total Heterotrophic Bacteria ranged between 4.28±1.37cfu/ml and 9.13±1.57cfu/ml, Total Coliform Bacteria (66.17±13.20MPN/100ml – 615.33±143.76MPN/100ml) and Fecal Coliform Bacteria (3.17±2.79MPN/100ml – 165.17±44.49MPN/100ml). In the sediment, the levels of the physicochemical characteristics ranged as follows: pH (5.95±0.64- 6.30±0.30); Electrical conductivity (2303.00±1238.20µs/cm – 3417.67±789.70µs/cm) and Phosphate (7.52±1.06mg/kg – 16.17±3.48mg/kg). The ranges of Chromium and Nickel ion levels were 0.89±0.30mgkg – 6.66±0.95mg/kg and 2.93±0.63mg/kg – 9.99±20mg/kg respectively. The levels of Cadmium and lead ions were below detection limit (0.001mg/kg. The water Quality index of (2098.62) showed that Okulu River might not be suitable for some domestic use.

Key Words: Water Quality Index, physicochemical properties, Okulu, Heavy metal levels, Microbiological Load, Eleme, Rivers State.

Introduction

Water is one of the most important and abundant resources in the earth surface (Umedum *et al.,* 2013). It covers more than 70% of the earth planet and is distributed

in nature as surface and ground water systems in form of Oceans, Seas, Rivers, lakes, ponds, wells, boreholes and springs (Igwe *et al.,* 2019). These sources are the most available sources of water used for domestic and other purposes by urban-rural communities in developing countries especially the sub Saharan Africa.

Water is essential to the lives of all living things on earth. In humans, water plays so many vital roles and forms major parts of the body cells. Water cushions and lubricates the brains and joints, circulation of nutrients and carries waste away from the body cells. Furthermore, it helps in the regulation of the body temperature by redistributing heat from active tissues to the skin and cooling the body through perspiration (Mohammad, 2015). Other essential roles of water to humans includes consumptions, cooking, laundering, agricultural activities and power generations.

Despite the abundance of water, access to quality water remains a very big challenge in the world especially in developing countries such as Nigeria. The growing demands for water coupled with the increase in pollution load due to anthropogenic activities threatens the quality of surface water bodies posing serious hazards to public health, agricultural and industrial production, ecological functions and biodiversity (World bank, 2003). The quality of surface water in sub Saharan Africa with its ecological integrity has raised concern due to the indiscriminate disposal of waste into the rivers (Abinah, 2013). These wastes can cause excessive damage to the water quality characteristics and the ecology of the environment especially when microbial degradation activities fail to remove these pollutants fast enough to prevent environmental degradation, creating a very harsh environment for marine micro-flora, fishes as well as other marine lives. Many diseases and deaths are directly related to poor drinking water as water related diseases kill a child every eight seconds and account for about 80% of illness and death in developing world. (Abinah, 2013).

The Water Quality Index (WQI) is defined as a rating that reflects the composite influence of different water quality parameters. (Allison *et al*. 2020.) It is considered as one of the most reliable and effective method of measuring water quality because it simplifies data into information that can easily be understood by concern citizens, researchers and policy makers. In this study weighted arithmetic mean method water quality index was used to evaluate the impact of some activities such as sand mining, petrochemical and abattoir effluent on Okulu River.

STUDY AREA.

Okulu River (Figure.1) is one of the fresh water systems located in Eleme Local Government Area of Rivers State. The River serves domestic, economic and recreational purposes; it is also a habitat for fishes and other aquatic organisms. Okulu River takes it course from Ogale meandering through Agbonchia and Aleto before emptying into Bonny River through Okrika creeks. A lot of industrial activities such as

petrochemical and fertilizer operations, sand mining as well as an abattoir processing facility litter around Okulu River. Station 1 is located at latitude 04.80790°N and longitude 007.09874°E. Activities around this location are sand mining, fishing and farming. Station 2 is located at latitude 04.80686°N and longitude 007.10099°E. Activities around this location are abattoir processing facility, car wash and auto mechanic. Station 3 is located at latitude 04.80786°N and longitude 007.10188°E. Activities around this location is farming and dredging. Station 4 is located at latitude 04.80847°N and longitude 007.10307°E. Activities around this location are fishing and NNPC pipeline right of way. Station 5 is located at latitude 04.80891°N and longitude 007.10556°E. The location is directly behind fertilizer processing plant.

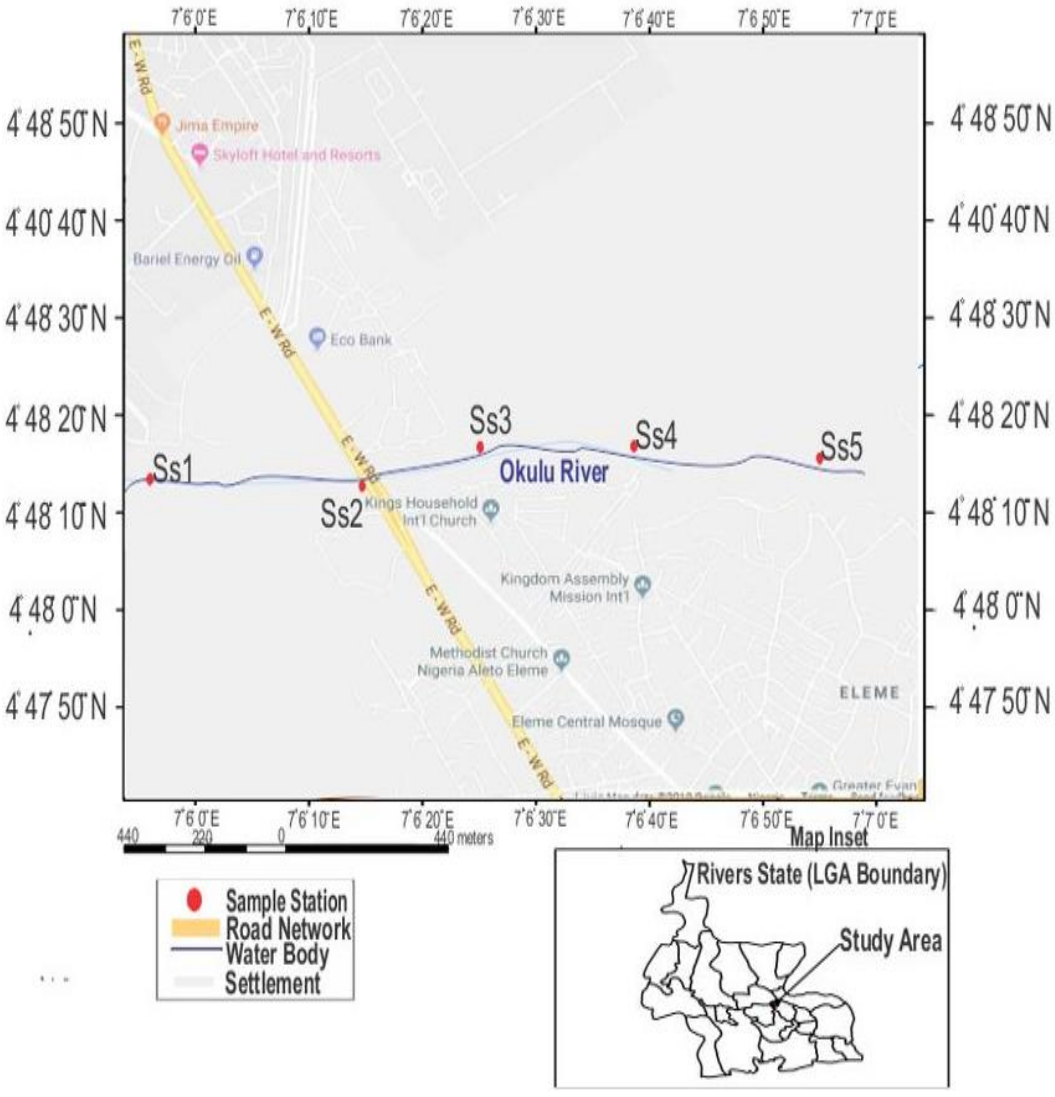


Figure. 1: Map of the Study Area

MATERIALS AND METHODS

Pre-Field Activities.

A reconnaissance tour of the study area was done and sampling stations were mapped using Global Positioning System (GPS). Sampling containers were obtained, washed, rinsed and labelled. Reagents for sample analysis were prepared and all the instrument to be used for the analysis were properly calibrated.

Fields/Laboratory Activities

Five sampling stations were established along the stretch of Okulu River, surface water samples were collected from each sampling points for a period of six months (July – December, 2019). Vials were used to collect water samples for microbial load, glass bottles were used to collect water sample for Total Hydrocarbon Content (THC) and heavy metals respectively while amber bottles were used for Dissolved Oxygen and Biochemical Oxygen demand. Water samples were stored in ice-chest and transferred to the laboratory for analyses.

In-situ measurement for Temperature, pH, Total dissolved solids and conductivity were determined using Mercury in glass thermometer and multiple- parameter Horiba water checker. The probe was rinsed with distilled water before inserting into the water sample and the mode was put on for the parameter to be measured. The probe was stirred in the water sample and allowed to stand until a stable value was displayed. The mode was changed for the analysis of other parameters and the values recorded. The chemical analysis of the water samples was done using standard laboratory methods as established by American Public Health Association (APHA). The suitability of Okulu River for domestic and other purposes were determined by comparing the values of the parameters obtained with WHO (2004) standard for drinking water.

In determining the Water Quality Index (**WQI)** in this study, 22 parameters namely Temperature, pH, Dissolved oxygen, Biochemical oxygen demand, Turbidity, Salinity, Chloride, Electrical conductivity, Total dissolved solids, Total hydrocarbon content, Calcium, Total Hardness, Ammonia, Phosphate, Magnesium, Chromium, Cadmium, Nickel, Lead, Total heterotrophic bacteria, Total coliform bacteria and Fecal coliform bacteria were considered. The weighted arithmetic mean method was used to classify the water quality according to the degree of purity using the most commonly measured water quality variables (Shweta et al. 2013.) using the formula:

$$WQI = \sum WiQi / \sum Wi$$

The quality rating (Qi) for each parameter is calculated by using the following:

$$Qi = 100(Ve-Vi/Vs-Vi)$$

Where

Ve = Experimental value, Vi = Ideal value, Vs = Standard value, Wi = K/Vs, Wi = Unit weight for each parameter, K= Proportional constant.

WQI Rating

Excellent <50
Good water 50-100
Poor water 200-300
Unsuitable for use >300

The results of the analysis are presented in Table 1.

RESULTS AND DISCUSSION

The results of the physicochemical variability of Okulu River shows that the average temperature, ranged from 29.033^{o}C to 29.817^{o}C. The temperature value was highest in station 1 and lowest in station 5. The temperature values for the whole stations throughout the study period were within WHO (2004) standard (10^{o}C– 30^{o}C) for water quality.

The mean pH shows that station 5 had the lowest pH (6.252) and station 1 highest with a pH of (6.728) for surface water sampled. The overall pH across all stations were neutral. The results also showed that there was no significant difference in the pH of the surface water sampled across the stations. The mean spatial pH of the surface water was within WHO standards.

Dissolved Oxygen (DO) values recorded in the study, ranged between 6.388 mg/l and 7.718 mg/l. The lowest value of dissolved oxygen was recorded in station 5 while the highest value was recorded in station 1. All the values obtained were within permissible limits of 7.5 except the value obtained in station 1 which was slightly higher. High DO can be as a result of high volume and velocity of water flowing into the River due to frequent rainfall (Ikhuoriah *et al*., 2013).

Biochemical Oxygen Demand (BOD) results ranged from 3.317 mg/l to 3.685 mg/l across all the stations. The values were within the limits specified by WHO. According to Oluwafisayo *et al*., (2017) BOD is classified based on fair measure of cleanness of any water such that values less than 2mg/l are clean, 3-5mg/l fairly clean while water body with 10mg/l and above is definitely bad and polluted.

Salinity values showed a range between 1.57ppt and 2.55pt. The low level of salinity is attributed to high rainfall, during this period high volume of fresh water is discharged into the river thereby diluting and causing lower salinity. According to Favour, (2016),

salinity is usually highest during the periods of low flows and increases as water level decreases.

Turbidity range was between 9.677 NTU and 19.868 NTU. High turbidity values were prevalent during the wet seasons. This is because of colloidal particles arising from clay and silt during rainfall (Eze, 2016).

Table 1 Spatial variation of physicochemical parameters of Surface Water (Mean±SD)

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	WHO
Temp	29.817±1.68	29.8±1.83	29.617±1.66	29.35±1.49	29.033±1.40	30
pH	6.728±0.44	6.587±0.42	6.372±0.39	6.322±0.35	6.252±0.48	6.5-8.5
DO (mg/l)	7.718±1.90	7.105±0.96	6.837±0.94	6.925±1.42	6.388±1.31	7.5
BOD (mg/l)	3.317±0.46	3.497±0.49	3.497±0.48	3.537±0.43	3.685±0.48	40
Turbidity (NTU)	16.305±7.99	19.868±9.68	16.188±10.37	9.677±5.91	10.563±3.27	50
Salinity (ppt)	2.553±1.26[a]	2.235±1.11	1.73±1.06	1.572±0.97	1.57±1.05	-
Cl (mg/l)	381.022±409.85	370.663±429.32	488.445±577.95	279.45±296.21	363.645±392.77	-
Electrical Conductivity (µS/cm)	5187.5±1071.23	4803.833±881.17	3755.5±301.13	3415.667±335.7	3070±491.67	100
TDS (mg/l)	2603±539.6	2411.667±441.44	1884±145.62	1713.5±164.52	1540.833±242.69	50
THC (mg/l)	1.3±1.52	1.805±2.23	1.12±1.25	1.007±1.26	0.874±1.18	100
Calcium (mg/l)	40.925±16.74	35.305±11.73	29.313±7.96	29.933±13.59	24.302±15.3	-
Total Hardness (mg/l)	162.242±88.12	155.382±89.02	157.475±61.11	146.147±42.77	161.223±56.78	500
NH_3 (mg/l)	0.073±0.11	0.023±0.02	0.022±0.02	0.037±0.06	0.022±0.02	0.3
PO_4 (mg/l)	0.028±0.02	0.028±0.02	0.032±0.03	0.107±0.1	0.025±0.03	5
Mg (mg/l)	13.377±13.81	17.198±16.34	17.313±12.67	14.38±1.39	20.402±7.13	20
Cr (mg/l)	<0.001±0	0.018±0.01	<0.001±0	0.015±0.01	<0.001±0	0.01
Cd (mg/l)	<0.001±0	<0.001±0	<0.001±0	<0.001±0	<0.001±0	0.01
Ni (mg/l)	<0.001±0	<0.001±0	<0.001±0	<0.001±0	<0.001±0	0.01
Pb (mg/l)	<0.001±0	<0.001±0	<0.001±0	<0.001±0	<0.001±0	0.01
THB	9.13±1.57	5.23±1.11	4.28±1.37	5.15±2.1	6.05±2.11	0
TCB	130.67±18.2	66.17±13.2	615.33±143.76	87.33±11.06	194.67±12.82	10
FCB	75.67±12.53	59.17±16.03	165.17±44.49	75.83±22.09	3.17±2.79	0

Chloride concentration in water ranged from 279.45 mg/l to 488.445 mg/l. The high concentration of chloride recorded across stations is likely due to the impact of abattoir effluents on the river (Eze, 2016).

Electrical conductivity value observed in Okulu River during the study ranged between 3070 μs/cm and 5187.5 μs/cm. Conductivity values are usually high during the dry season, this maybe because water is warmer during the dry season, as stated by Ajibare et al., (2014) the warmer the water the higher the conductivity.

Total dissolved Solids (TDS) value ranged from 1540.833 mg/l to 2603 mg/l. The high value of TDS recorded across stations is due to the presence of sewage and industrial waste in the water body (Abinnah, 2013).

Total hydrocarbon content- the value obtained ranged from 0.874 mg/l to 1.805 mg/l, these values were significantly lower than WHO standard of 100mg/l.

The concentration of calcium recorded during the study ranged from 24.302 mg/l to 40.925 mg/l and are within WHO standard of 500mg/l.

The results of ammonia concentration ranged from 0.022 mg/l to 0.073 mg/l, these values fall below WHO limits of 0.3mg/l.

The spatial variation of phosphate concentration ranges from 0.025 mg/l to 0.107 mg/l, these values falls below WHO limits of 5.0 mg/l. Large concentration of this nutrient accelerate plant growth (Eze, 2016).

Magnesium level recorded across the stations ranged from 13.377mg/l to 20.402 mg/l. All stations fall within WHO standards of 20mg/l except the value obtained in station 1 which was slightly higher.

Total hardness values recorded ranged between 146.147 mg/l and 162.242mg/l. The value recorded in station 1 was higher than the values recorded in other stations. All the values recorded were below WHO standard of 500mg/l.

Heavy metal Levels

Cadmium, nickel, chromium and lead concentration were below 0.01mg/l except the values of 0.018mg/l and 0.015mg/l for chromium in station 2 and 4. According to Samuel, (2015), heavy metal presence in water bodies occurs largely due to anthropogenic activities such as industrial processes, agricultural activities and disposal of wastes.

Microbiological Characteristics of the water

The results of the microbial content of Okulu River shows that Total Heterotrophic Bacteria (THB) ranged from 4.28cfu/ml to 9.13cfu/ml. Total Coliform Bacteria (TCB) ranged from 66.17MPN/100ml to 615.33MPN/100ml and Fecal Coliform Bacteria (FCB) ranged from 3.17MPN/100ml to 165.17MPN/100ml. The microbial content of Okulu River was very high due to the input from human activities such as poor standard of hygiene, sanitation, contaminants from both humans and animal waste (Edessa *et al*., 2017). The determination of water quality index of Okulu River is shown in Table 2.

Table 2. Water quality index study of Okulu River.

Parameters	Ci	Si	Qi	Wi	Qi*Wi
Temp	29.5233	30	98.4111	0.03333	3.28037
pH	6.452	8.5	75.9059	0.11765	8.9301
DO (mg/l)	6.99467	7.5	93.2622	0.13333	12.435
BOD (mg/l)	3.50633	39.9	8.7878	0.02506	0.22025
Turbidity (NTU)	14.5203	50	29.0407	0.02	0.58081
Salinity (ppt)	1.932	-			
Cl (mg/l)	376.645	250	150.658	0.004	0.60263
Electrical Conductivity (µS/cm)	4046.5	100	4046.5	0.01	40.465
TDS (mg/l)	2030.6	500	406.12	0.002	0.81224
THC (mg/l)	1.22103	300	0.40701	0.00333	0.00136
Calcium (mg/l)	31.9557	-			
T.Hardness (mg/l)	156.494	500	31.2987	0.002	0.0626
HN_3 (mg/l)	0.03533	0.03	117.778	33.3333	3925.93
PO_4 (mg/l)	0.044	5	0.88	0.2	0.176
Mg (mg/l)	16.534	20	82.67	0.05	4.1335
Cr (mg/l)	0.00707	0.05	14.1333	20	282.667
Cd (mg/l)	0.001	0.01	10	100	1000
Ni (mg/l)	0.001	0.01	10	100	1000
Pb (mg/l)	0.001	0.01	10	100	1000
THB	5.97	1	597	1	597
TCB	218.8333	100	218.8333	0.01	2.188333
FCB	75.8	1	75800	10	75800
				∑Wi = 364.94	**∑Qi * Wi = 765879.5**

WQI = 2098.62

Excellent <50
Good water 50-100
Poor water 200-300
Unsuitable for use >300

Ci = Average concentration of each parameter.
Si = permissible limit for each parameter.

Conclusion

The results of the six months physicochemical and microbiological evaluation of Okulu River revealed that the water is contaminated and capable of having negative impact on the health of the consumers. The high-level concentration of the microbial load of the water is an indication that the water is contaminated with both humans and animal waste.

RECOMMENDATION.

Proper sensitization on personal and environmental hygiene should be made on the communities that use the water in order to safeguard their health as well as the environment.

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