Determination of Water Quality Indices of the Freshwater Stretch of Orashi River, Ahoada West Local Government Area of Rivers State

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Abstract: The study evaluated the physicochemical characteristics, microbial load and some heavy metal levels of freshwater stretch of Orashi River in Akinima, Ahoada west Local government area of Rivers state, Nigeria, with the aim of determining the water quality indices of the freshwater, since inhabitants utilize it for domestic purposes. Samples were collected from 5 sampling stations and analyzed using standard methods of analysis. The pH, electrical conductivity, temperature, alkalinity, total hardness, total dissolved solids and turbidity levels ranged from 5.98±0.48 – 6.61±5.98, 23.13 ± 8.57 –31.78 ± 5.17 µS/cm; 27.34 ± 1.48 – 27.50 ± 1.39 ^{o}C; 4.95±1.00 – 8.85±3.11mg/l; 29.89 ± 11.54 – 60.60 ± 9.34 mg/l; 16.95 ± 3.36 – 20.85 ± 1.25 mg/l and 6.42 ± 0.84– 13.34 ± 5.56 NTU respectively. DO, BOD and COD levels were 6.24 ± 1.43 – 6.84 ± 0.52 mg/l, 3.09 ± 1.14 – 3.63 ± 0.72 mg/l and 8.22 ± 2.54–16.59 ±4.94 mg/l respectively. Nitrate ranged from 0.14 ± 0.43– 0.37 ± 0.51mg/l, Chloride (5.96 ± 1.17 –11.81± 2.21mg/l); Phosphate (0.03 ± 0.001–0.44 ± 0.43 mg/l) and Sulphate (3.06 ± 1.53 –5.11 ± 1.52 mg/l). Trace metals gave Mn (0.005 ± 0.005– 0.018 ± 0.018 mg/l), Cu (0.018 ± 0.032– 0.252 ± 0.116 mg/l); Cr (0.003 ± 0.012 – 0.005 ± 0.002 mg/l), Pb (0.010 ± 0.000–0.008 ± 0.005mg/l) and Zn (0.029 ± 0.034 – 0.073 ± 0.008 mg/l). Total coliform indicated 4.75 ± 1.71 – 10.75± 2.31CFU/100 ml, Faeccal Coliform (0.50± 1.00 – 0.75 ± 1.50 CFU/100 ml); Total Heterotrophic Bacteria (3857.50 ± 2616.70 – 6165.00± 4086.83 CFU/100 ml) and Total Heterotrophic Fungi gave counts of 4,725.00 ± 2066.19 – 11725.00 ± 1268.53 CFU/100 ml). Although some physicochemical characteristic of the freshwater stretch including trace metals analyzed were within the national and international permissible limits, that of pH, COD and Sulphate exceeded the permissible limits. Microbial loads were high in the freshwater stretch when compared to the recommended limits. The computed water quality index for the freshwater stretch had value of 35.87. Results revealed deterioration in the quality of the freshwater stretch. Conclusively, the freshwater stretch of Orashi River in Akinima, Ahoada West L.G.A of Rivers state might not be fit for human consumption.

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1. Introduction

Water is one of the earth's natural resources and covers three quarters of the earth's surface water and is an essential resources that supports all forms of plants and animal life (Garry and Stephen,2015). The increase in the need for freshwater brought about by increase in human population and rise in industrialization has resulted in the scarcity of this unique resources (Lawson,2011). Water stress, which is a situation where there is deterioration in the quality and quantity of available freshwater in the environment has resulted to the monitoring and evaluation of the freshwater systems (Garry and Stephen,2015).

In Nigeria water contamination occurs both in the urban and rural areas. Most of the rural communities use river water as the most common source of drinking water in addition to bore-hole and the streams. The water bodies water are most often contaminated by organic substances from people that leave at the upstream who use the water bodies for industrial and agricultural activities. The incessant human activities along rivers and the streams results in the alteration of the ecological state of the receiving water system (Arimo and Ikomi, 2008). Furthermore, human health maybe in danger by the excessive use of chemical fertilizers in farming along the river banks as well as by defecation, and other unwholesome activities, including dumping of refuse in the freshwater systems (Okereke and Igboanua,2003). In view of the water stress in our freshwater systems, the various freshwater bodies need to be protected from unwholesome activities that go on in them.

This is because abuse of the water bodies lead to significant stress to the habitats as well as the microbiological organisms in the freshwater body (Akpan, 2004). A freshwater stretch of Orashi River

at Akinima, Ahoada west local government area of Rivers States, serves as a source of portable water, domestic uses and as well as industrial purposes. However, the river is constantly been perturbed by unwholesome activities like defecation, dumping of refuse, sand dredging, introduction of chemicals through washing and bathing. The impacts of these activities on the quality of the freshwater body are unknown as there are dearth of information regarding the water quality indices of the freshwater stretch at Akinima. Therefore, the study was aimed at determining the water quality indices of the freshwater stretch.

2. Materials and Methods

The study was carried out in Akinima stretch of Orashi River, Ahoada West local government area of Rivers State, Nigeria. The five sampling stations in the freshwater stretch lies between the following latitudes, (5°2′ 38.04″N, 5°2′41.66″N, 5°2′48.10″N, 5°2′10.85″N, 5°2′10.85″N) and longitudes (6° 27′ 4.71E, 6° 27′5.63E, 6° 27′5.62E, 6° 26′59.01E, 6° 26′52.49E) (Fig. 1).

2.1 Sampling Stations

Five sampling stations were identified based on the nature of activities going on along the river stretch and accessibility. Station 1 is located upstream, the stretch has a lot of vast flood plain, has a relatively high flow and sandy floor. Human activity here includes local sand dredging and fishing. Station 2 is located downstream of station 1. The station is characterized with grasses and shrubs. The station has a moderate flow rate. Major activities that take place here include bathing and washing of cloths. Station 3 is located downstream of station 2. It is characterized by moderate flow and a vast flood plain.

Activities that take place here include bathing and recreational exercises. Station 4 is located downstream of station 3. The station has a lot of green vegetations with a moderate flow rate. Major human activities that take place in this station include fishing, farming and recreational exercises. Station 5 is located downstream of station 4. The station is characterised with dense vegetation the major activities that takes place this station is farming and washing.

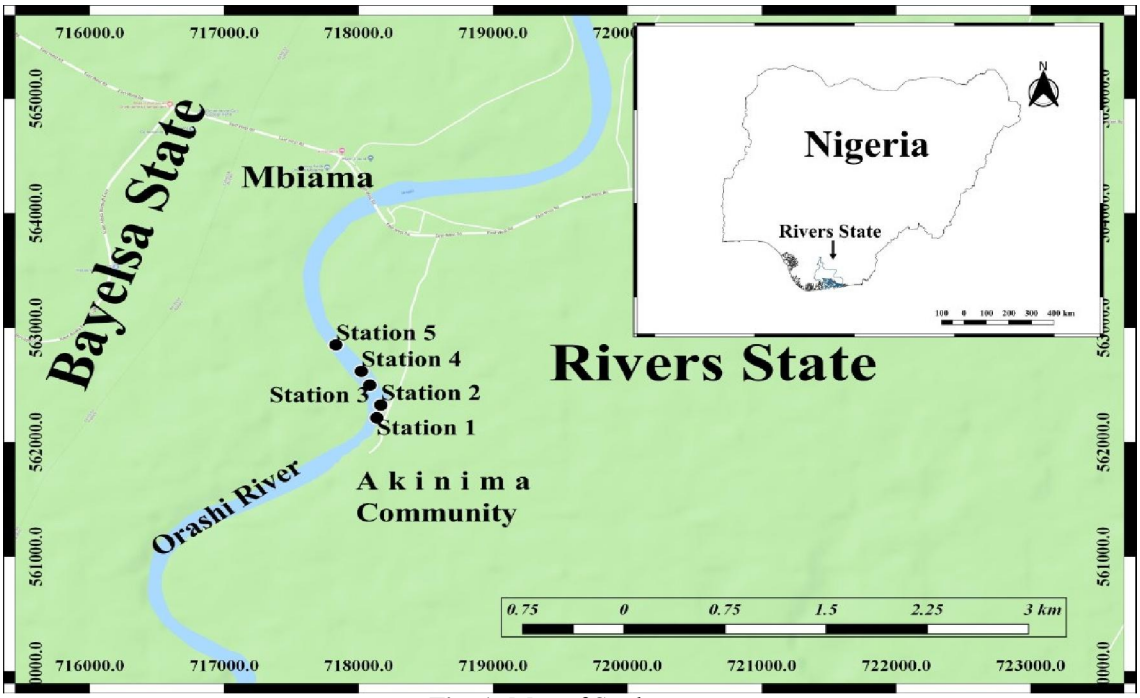

Fig. 1: Map of Study area

2.2 Water Sampling

Sampling of the freshwater body was carried out during the wet season from downstream to upstream, once monthly for a period of four months (June – September). Samples were collected in various containers, samples for measurement of physicochemical parameters, and heavy metal concentrations were collected separately in plastic containers. For the sampling of heavy metals, few drops of concentrated HNO_3 were added to for the preservation of the samples.

For Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD) amber bottles were used while glass bottles

were used to store samples for organic parameters and sterile cap bottles were used for microbiological samples examination. The samples were immediately stored on ice-packed cooler box and then transported to the laboratory for analysis within twenty four hours of collection. All the analyses were done based on standards methods of analysis for each water quality parameter.

2.3 Analysis of Physicochemical Parameters

The surface water temperature was measured in situ at the sampling stations with mercury in-glass thermometer. The bulb of the thermometer was immersed in the surface water and held in a fixed position for about five minutes and allowed to stabilize, thereafter, a constant reading was obtained and recorded in degree centigrade (^{o}C). Orion Star A121.2010 digital pH meter was used for the determination of the Ph of the surface water. Dissolved Oxygen was determined by the use of Modified Azide method (APHA, 2005). Turbidity levels were measured in Nephelometric units (NTU) in the laboratory by the use of digital multi-meter (Orion Star A121, 2010). In order to determine the Biological Oxygen Demand (BOD_5) of the surface water sample for this study, the water sample was incubated at a temperature of 20 ◦C for five days after which the dissolved oxygen levels were determined again.

The difference in the dissolved oxygen values before and after incubation gave the value of the biological oxygen demand (BOD_5). The analysis of other parameters Electrical Conductivity (EC), Total dissolved solids (TDS), Chemical Oxygen Demand (COD), Alkalinity, Total Hardness, the Anions (nitrates, chlorides, sulphates, phosphates), metals (manganse, copper, chromium, nickel and lead) and Microbiological parameters (Total coliform, faecal coliform, Total heterotrophic Bacteria and Total heterotrophic Fungi), followed standard methods of analysis (APHA,2005) in the laboratory.

2.4 Data Analysis

Calculations of the mean and standard deviation for each parameter and stations were made. The data obtained from the study were subjected to statistical analysis. Analysis of variance (ANOVA) at ($p<0.05$) was carried out to check if there was a significant difference among heavy metals at different sampling stations.

2.5 Calculation of Water Quality Index (WQI)

The Water quality index was computed using the weighted Arithmetic index method.

3. Results and Discussions

The results of the physicochemical and microbiological properties at the five sampling stations are presented in table 1. Results obtained from the study showed, pH (5.98 ± 0.48 to 6.61 ±5.98), conductivity (23.13 ± 8.57µS/cm to 31.78 ±5.17µS/cm), 27.34±1.48 ^{o}C to 27.50 ± 1.39˚C, Alkalinity (4.95±1.00mg/l to 8.85±3.11mg/l), Total Hardness (29.89 ± 11.54 mg/l to 60.60 ± 9.34 mg/l), Total dissolved solids (16.95 ±3.36mg/l to 20.85 ±1.25 mg/l), Turbidity (6.42±0.84 NTU to 13.34 ± 5.56 NTU), Dissolved Oxygen (DO) (6.24 ± 1.43mg/l to 6.84±0.52 mg/l), Biological Oxygen Demand (3.09±1.14 mg/l to 3.63±0.72 mg/l), Chemical Oxygen Demand (COD) (8.22±2.54 mg/l to 16.59 ± 4.94mg/l); Anions are phosphate (0.03± 0.001mg/l to 0.44 ± 0.43mg/l), sulphate (3.06 ± 1.53mg/l to 5.11 ±1.52mg/l), nitrate (0.14± 0.43 mg/l to 0.37±0.51mg/l) and chloride (5.96 ±1.17mg/l to 11.81±2.21mg/l); all the metals varied closely with one another from one station to another. Mn (0.005 ± 0.005 mg/l to 0.018 ± 0.018 mg/l, Cu (0.018 ± 0.032mg/l to 0.252 ± 0.116 mg/l), Cr (0.003 ± 0.012mg/l to 0.005 ± 0.002 mg/l), Ni (0.009 ± 0.000 mg/l, Pb (0.010±0.000 mg/l to 0.008±0.005mg/l) and Zn (0.029± 0.034mg/l to 0.073 ± 0.008 mg/l); the microbiological parameters are Total coliform (4.75± 1.71CFU/100ml to 10.75±2.31 CFU/100ml), Faecal coliform (0.50±1.00CFU/100 ml to 0.75± 1.50 CFU/100ml) THB (3857.50 ± 2616.70 CFU/100 ml to 6165.00±4086.83CFU/100 ml) and THF (4,725.00 ± 2066.19 CFU/100 ml to 11725.00 ± 1268.53 CFU/100ml).

The mean pH (5.98±0.48 – 6.61±0.61) is a reflection of slight acidic nature of the water body. Permissible pH levels in freshwater systems range between 6.5 and 8.5. The surface water may therefore be corrosive and may require treatment before consumption. The level recorded in this study were low compared with levels (6.52 – 7.06) reported by Enetimi *et al.* (2016) in the quality assessment of Orashi river as well as 6.77 – 7.08 levels recorded by Arimieari *et al.* (2014) in some selected freshwater in Port Hg6arcourt. Temperature levels recorded in the Akinima stretch of Orashi River was within National and International limits (NIS, 2007, WHO, 2011).This maybe as a result of reduced sunlight experienced during the period of the study as it was at the zenith of wet season.

The levels recorded in this study is higher compared to (26.37 – 26.77˚C) reported by Enetimi et al., (2016) in the quality assessment of Orashi river as well as (27˚C - 32˚C) level recorded by Ogamba *et al.* (2004) in Elechi Creek. The mean levels of Electrical Conductivity (EC), Hardness, Total Dissolved Solid (TDS), chlorides, sulphates, and nitrate in the water body were within the permissible limits. The mean phosphate (PO_4^{2-}) (0.03±0.01mg/L – 0.44±0.43mg/L) was slightly higher compared to permissible limits.

Therefore, the computed water quality index (WQI) for the river stretch is 35.87 and this value falls into a water that is polluted and not fit for drinking. This might be as a result of washing and bathing activities as well as runoff from farm land in the vicinity to this river stretch. Phosphate levels recorded in this study were higher when compared with (0.11 – 0.8mg/L) as recorded in a study conducted by Wokoma and Njoku, (2017) in the lower Sombreiro River in Rivers State. The turbidity value ranged from (6.42±0.84NTU to 13.43±5.56NTU). The value obtained in this study is above the National and International limits (NIS, 2007, WHO, 2011). This implies the presence of solid particles in the river and may therefore imply increased anthropogenies inputs in the river.

Table 1: Physicochemical Characteristics, Heavy Metals and Microbiological Properties of Surface water of Akinima Stretch of Orashi River

Parameter	Station 1	Station 2	Station 3	Station 4	Station 5
pH	6.61±0.61	6.35±0.75	6.21±0.79	6.01±0.46	5.98±0.48
EC (µS/cm)	31.78±5.17	26.30±6.87	23.45±4.45	25.35±7.38	23.13±8.57
Temperature (˚C)	27.43±1.48	27.88±2.16	27.55±1.72	27.65±1.69	27.50±1.39
Alkalinity ($mgCaCO_3/l$)	4.95±1.09	8.85±3.11	7.46±0.63	6.07±1.47	5.01±1.12
Total Hardness ($mgCaCO_3/l$)	31.70±15.86	54.40±9.77	60.60±9.34	33.19±5.97	29.89±11.54
TDS (mg/l)	20.85±1.25	17.2±4.04	16.95±3.36	18.97±5.64	17.82±4.85
Turbidity (NTU)	12.82±2.09	8.56±0.65	10.85±2.13	6.42±0.84	13.43±5.56
DO (mg/l)	6.84±0.52	6.29±1.52	6.35±1.54	6.24±1.43	6.37±1.41
BOD (mg/l)	3.63±0.72	3.53±0.96	3.23±1.57	3.09±1.14	3.55±0.86
COD (mg/l)	8.41±1.06	16.09±2.07	16.59±4.94	8.31±0.87	8.22±2.54
Sulphate (mg/l)	0.15±0.09	0.34±0.20	0.37±0.51	0.21±0.17	0.14±0.16
Chloride (mg/l)	5.46±1.17	9.25±2.94	8.98±1.73	11.81±2.21	5.95±1.38
Phosphate (mg/l)	0.07±0.03	0.44±0.43	0.09±0.06	0.03±0.01	0.06±0.05
Sulphate (mg	5.11±1.52	4.99±0.43	4.76±0.75	3.31±0.49	3.06±1.53
Mn (mg/l)	0.018±0.018	0.009±0.002	0.006±0.005	0.005±0.005	0.013±0.013
Cu (mg/l)	0.252±0.116	0.095±0.045	0.028±0.008	0.018±0.032	0.038±0.041
Cr (mg/l)	0.005±0.002	0.003±0.012	0.005±0.002	0.003±0.000	0.004±0.009
Ni (mg/l)	0.090±0.000	0.09±0.000	0.09±0.000	0.09±0.000	0.09±0.000
Pb (mg/l)	0.010±0.000	0.010±0.000	0.008±0.005	0.008±0.005	0.008±0.005
Zn (mg/l)	0.073±0.008	0.029±0.034	0.032±0.024	0.048±0.045	0.019±0.025
Total Coliform (MPN/100ml)	8.00±2.16	4.75±1.71	10.75±2.13	13.5±9.68	10.25±8.54
Faecal Coliform (MPN/100ml)	0.50±1.00	0±0.00	0±0.00	0.75±1.50	0.0±0.00
THB (CFU/100ml)	4274.75±2786.62	4425.0O±2502.49	3857.50±2615.70	6165.00±4086.83	4928.90±4194.20
THF (CFU/100ml)	390.00±220.00	725.00±170.78	2065.00±3292.95	850.00±300.00	1272.50±1228.96

The levels recorded in this study is lower compared with levels (22.17 – 31.23 NTU) reported by Enetimi *et al.* (2016) in quality assessment of Orashi river. Whereas the levels of Dissolve Oxygen (DO), Biochemical Oxygen Demand (BOD_5) recorded in this study were within the permissible limits of 5 – 7mg/L and 2 -5mg/L (WHO, 2011), the levels of Chemical Oxygen Demand (COD) were higher than the permissible limit, (WHO, 2011). The low level of BOD obtained could be as a result of low level of biochemical degradation of organic matter in the water by micro-organisms, which is also clear as the reason for the lower level of Dissolved Oxygen (DO). The values of DO and BOD were lower compared to (5.80 – 15.7mg/L) and (4.00 – 6.97mg/L) for DO and BOD recorded by Enetimi *et al.* (2016) in Orashi River.

The low level od BOD observed in the Akinima stretch of Orashi river can be as sign of low organic pollution of the water body. Whereas manganese, copper, chromium, lead and zinc were all below the National and International limits (NIS, 2007, WHO, 2011), nickel levels (0.090±0.000mg/L) exceeded the international level limit of 0.07mg/L (WHO, 2011).

Table 2: Computed WQI value for Akinima Stetch of Orashi River

Physicochemical Parameter/Unit	Concentration (C_I)	Mean standard permissible Value (s_i)	Relative Weight (W_i)=1/s_i	Quality Rating scale Q_i=(c_i/s_i x100)	Q_iW_i
pH	6.23±0.26	7.5	0.133	83.067	11.048
EC (µS/cm)	26.00±3.49	750	0.0013	3.467	0.0045
Hardness (mg/L)	41.96±14.41	500	0.002	8.392	0.0168
TDS (mg/L)	18.35±1.61	500	0.002	3.670	0.0073
Turbidity (NTU)	10.41±2.94	1	1	1041	I041
DO (mg/L)	6.42±024	6	0.167	107	17.869
BOD_5(mg/L)	3.41±0.23	3.5	0.286	97.429	27.865
COD (mg/L)	11.52±4.40	10	0.100	1152.2	11.52
Nitrate (mg/L)	0.24±0.11	50	0.020	0.480	0.0096
Chloride (mg/L	8.29±2.61	250	0.004	3.316	0.0132
Sulphate (mg/L)	4.25±0.98	400	0.0025	1.063	0.0027
Manganese (mg/L)	0.010±0.005	0.005	200	200	1
Copper (mg/L)	0.086±0.097	2	0.500	4.3	2.15
Chromium (mg/L)	0.004±0.001	0.005	20	8	160
Nickel (mg/L)	0.09±0.00	0.07	14.286	128.57	1836.77
Lead (mg/L)	0.009±0.001	0.01	100	90	9000
			ΣW_i= 337.50		ΣQ_iW_i= 12,109.276

WQI =$\Sigma Q_iW_i/\Sigma W_i$= 12,109.276/337.50=35.87

The high levels of nickel may be attributed to anthropogenic activities arising from domestic waste, oil leakage and runoff. Heavy metal, even in trace amount is toxic (Chapman, D. V., 1996) and therefore render the surface water unfit for human consumption. metal levels recorded in the surface water were a bit lower compared with higher level reported by Enetimi *et al.* (2016) in Orashi River as well as comparable to the levels reported by Chukwujindu *et al.* (2007) in Ase River, Delta State. The high level of nickel recorded in the surface water may result to nickel toxicity whereas some measured properties of the surface water were within regulatory standards.

Levels of pH, COD, phosphate and nickel were higher than their permissible limits, thereby impairing the use of surface water for consumption. A mean Total Coliform value of 9.45±3.28 CFU/100ml, mean faecal coliform value of 0.25±0.35CFU/100ml, mean (THB) value of 4730.23±888.86CFU/100ml and a mean (THF) value of 1060.40±644.24CFU/100ml were recorded in the surface water. According to (WHO, 1996), guideline for drinking water qualities, bacteria contaminants are not supposed to be detected in the surface water if it is to be used for drinking. Summarily, based on the result obtained in this study, the surface water is unfit for consumption and requires treatment before use.

4. Conclusion

Although, Akinima stretch of Orashi River is a freshwater, the water quality index (WQI) value of 35.87 computed from the study shows mild pollution of the river stretch. Futhermore, it was not fit for human consumption as a result of human activities in the river stretch which have contributed to slight increase in the acidity, increase in phosphate, high levels of nickel and presence of bacteria contaminant in the water body that can cause some health challenges when consumed without treatment.

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