



Water Quality Assessment of Osse River, Gele-gele: A Tributary of Benin River, Southern Nigeria

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ABSTRACT: The physical/chemical characteristics and some heavy metals of Osse River, Gele-gele, Southern Nigeria was assessed during the dry and wet seasons. Four stations were studied from upstream to downstream with an average distance of 500meters between each station. A total of twenty-one (21) physical/chemical parameters were studied. pH ranged from 6.2-7.5, Suspended Solid 4-48mg/l, Turbidity 0-39NTU, Electrical Conductivity 20-110 μ S/cm, Alkalinity 8-48mg/l, Chloride 7.1-17.7mg/l, Hardness 8-56mg/l, Phosphate 0.01-0.53mg/l, Sulphate 5-33mg/l, Nitrate 1.2-9.3mg/l, Dissolved Oxygen 2.0-8.4mg/l, Biochemical Oxygen Demand 0.6-5.8mg/l. Heavy metals level generally ranged from 0.1 to 1.8mg/l for Iron, Zinc 0.0 to 0.93mg/l, Chromium 0.0 to 0.65mg/l, Cadmium 0.0 to 0.041mg/l, Lead 0.0 to 0.26mg/l, Manganese 0.0 to 0.082mg/l, Copper 0.0 to 0.059mg/l, Nickel 0.0 to 0.49mg/l. The mean concentration of metallic ions in Station 3 was significantly higher across the four sampled, with manganese, iron, cadmium, and copper responsible for this difference. Water Quality Index showed that all four stations had a range of 8.03-9.07. The concentration of the metals in the Osse river are within background concentration level, the mean Dissolved Oxygen and Biological Oxygen Demand obtained indicate the water is rated between fairly clean and clean, and the Water Quality Index indicates excellent water quality. Thus, the water is presently suitable for domestic use, but its quality may deteriorate with time if the current rate of anthropogenic activities around the water body is not curtailed.

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The health of aquatic and terrestrial life is to a large extent a direct consequence of the health of surrounding water bodies. Water is one of the most important components of life and life without it is impossible. However, due to increasing anthropogenic activities and some natural processes, the quality of water is decreasing continuously and is posing a great threat to all forms of life including humans. In Nigeria and other developing nations, pollution of water resources has become a serious problem (Ogundiran *et al.*, 2010). It is a major cause for the spread of many epidemics and some serious diseases like cholera, tuberculosis, typhoid, diarrhea etc. The contaminants in these waters, reaching aquatic ecosystems directly or indirectly occur in different forms, and the most stable of them are the heavy metals (Adamiec and Helios-Rybicka, 2002). Water pollution heightens the threshold of heavy metals and this usually poses a serious threat to human health, natural and semi-natural ecosystems (Battaglia *et al.*, 2005). Rivers are a dominant pathway for metals transport (Mohiuddin *et al.*, 2010).

River Osse is of immense importance to inhabitants along the river bank. They rely mainly on the river for their domestic water supply, fishing, and inter-village

transportation. The river also receives effluents from sawmills and fallout from oil exploration activities. A few studies have been carried out on the physical and chemical characteristics of the surface water of Osse River, however, none has reported the water quality index (WQI) of this water body. The water quality index (WQI) is a time - based unit less number between 1 and 100 that expresses the overall quality of water as a reflection of the composite influence of the different water quality parameters in a particular location (Yisa *et al.*, 2012). Therefore the use of WQI in the assessment of water quality is important in the monitoring and management of water source. This study is justified by the need to assess the water quality of Osse River using surface water to ascertain the level of anthropogenic influence in this water body. The aim of this paper is to present the data obtained as a consequence of the assessment of physical/chemical characteristics of a section of Osse River, Gele-gele a tributary of Benin River, Southern Nigeria and thus, provide baseline data on the water quality.

MATERIALS AND METHODS

Study Area: The study is on a stretch of Osse River that transverse through Gelegele to Izedema

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Communities within the tropical rainforest belt in Ovia North-East Local Government Area of Edo State, Southern Nigeria. Osse River stretches between latitudes 06° 12'N and 06° 10'N and longitudes 05° 20'E to 05° 22'E in Ovia North-East Local Government Area of Edo State. Osse River drains into the Benue River which empties itself into the Atlantic Ocean. This study area falls within the rainforest belt of Nigeria, with a wet season (March to October) and a dry season period (November to March). The River is fairly wide and flanked by secondary vegetation of *Hevea brasiliensis*, *Elaeis guineensis*, *Bambusa* sp. and shrubs. On the river are floating vegetation such as *Lemna* sp. and *Eichhornia crassipes*. A prominent landmark in the area is the presence of Dubril oil company facilities and their tug boat and badge. A Sawmill is also located along the stretch of the river from Gelegele to Izedema.

Four sampling stations randomly were selected. Station 1 is located along a section of Osse River 06° 15.236'N, 005° 33.625'E. This station is upstream and empties into station 2 partly because of a diversion that occurred some meters away from station 1. Station 2 is located at the entry point of Gelegele community 06° 15.511'N, 005° 34.355'E. This station is residence to only but a few families and is used as a site for washing and bathing and receives other domestic waste because of its proximity to the settlers. Station 3 is located at Dubril oil flow station along the river 06° 16.033'N, 005° 34.960'E. Gas is constantly flared at this station, and the flare is only fairly higher than the tallest building within the catchment area. This station is used as a site for washing and bathing by young people in the community because it is easily assessed. Station 4 is located at Izedema close to the evil forest along the Gelegele river course (downstream) at 06° 16.458'N, 005° 34.942'E. Logging activities take place close to this station.

Sampling: Water samples were collected monthly for 10 months from September 2014 to June 2015, between 0700hrs and 0900hrs on each sampling day. A total of 27 samples were collected and analyzed during the study period. The in-situ measurement was carried out using a pH meter for pH, TDS/Conductivity meter for electrical conductivity. Dissolved Oxygen and Biochemical Oxygen demand were estimated using Winkler's method. The BOD was carried out after 5 days of incubation at 20°C. The other physical/chemical characteristics were examined using standard method (APHA, 1998). The heavy metals such as Iron, Lead, Cadmium, Zinc, Copper, Chromium, Manganese, Nickel, and Vanadium were determined using Atomic Absorption

Spectrophotometer (Buck Scientific Atomic Absorption Spectrophotometer).

Data analysis: Inter-station comparison was done using Analysis of variance (ANOVA) and Duncan Multiple Range (DMR) test was performed to determine the point of significant difference. All statistical analyses were performed using Microsoft Excel (2010) package and SPSS 16.0 (Ogbeibu, 2005). The Water quality index (WQI) was calculated using the Weighted Arithmetic Water Quality Index Method (Akter *et al.*, 2016; Oboh and Agbala, 2017). The reference standard utilized for the calculation was the water quality criteria of the Nigerian Federal Ministry of Environment (FMEnv).

WQI was calculated by using the following equation:

$$WQI = \sum W_i Q_i / \sum W_i$$

Where; Unit weight for each water quality parameter (W_i) = K / S_i

Quality rating scale (Q_i) = $100 [(V_i - V_o) / (S_i - V_o)]$

K (proportionality constant) is calculated as $K = 1 / \sum (1 / S_i)$

V_i = Estimated Concentration of the i th parameter of interest in the analysed water.

V_o = The ideal value of the i th parameter in pure water ($V_o = 0$ if pH = 7.0; and DO = 14.6 mg/l⁻¹)

S_i = Recommended Standard value of the i th parameter by the FMEnv.

Table 1 illustrates water quality ratings according to the Weighted Arithmetic Water Quality Index method (Tyagi *et al.*, 2013)

Table 1: The rating of water quality

Levels	Rating of Water Quality	Grading
0 – 25	Excellent water quality	A
25 – 50	Good water quality	B
51 – 75	Poor water quality	C
76 – 100	Very poor water quality	D
> 100	Unsuitable for drinking purposes	E

RESULT AND DISCUSSION

Physicochemical Characteristics: The results of the physical/chemical characteristics of water from Osse River at the different sampling stations is illustrated summarized in Table 2. The pH of the river ranged from 6.2-7.5 indicating that the river was slightly acidic to moderately alkaline and falls within the WHO limit. There was no significant difference across the sampled stations. This pH range agrees with Welcome (1979) that rivers that flow through

rainforest regions are slightly acidic to neutral. This is due to the humic acid content arising from the decompositions and oxidation of organic matter in them (Deekae, 2010). The range recorded in this study is very close to those recorded in the Niger Delta waters of Nigeria (Omoigberale and Ogbeibu, 2007). The Total Suspended Solids ranged from 4mg/l – 48mg/l in this study and showed no significant difference across the stations. The average suspended solid exceeded the WHO limit, which may have been due to the amount of erosion around the upstream. The values obtained in this study is lower than that obtained from previous studies in Lagos Lagoon complex (Agboola *et al.*, 2008). Turbidity ranged from 7mg/l to 39mg/l in the study area and there was no significant difference across the sampled stations. The average turbidity also exceeded WHO limit. The mean value decreased slightly from station 1 to 3 before slightly increasing in station 4; this could be attributed to the organic constituents and human activities in the river system (Anyanwu, 2012). Conductivity ranged from 20 μ S/cm to 110 μ S/cm in the study area. The average value did not exceed WHO standard. This indicates the basic characteristics of the freshwater body (Anyanwu, 2012). Chloride concentration which could be used to check for possible saline intrusion in future ranged from 7.06mg/l to 21.18mg/l in this study and was not significantly different across the station. The average value fell within WHO standard but was relatively lower than the values obtained in Ogba river and Osse River in Benin City, Owo River and Ologe lagoon in Lagos (Omoigberale and Ogbeibu 2007; Yusuf and Osibango, 2007; Anyanwu, 2012). This is also a clear indication that the river was completely freshwater type in all the study stations. The Nitrate concentration obtained was relatively high (1.2mg/l to 9.3mg/l) unlike those reported for some in-land waters by Omoigberale and Ogbeibu 2007. This could be attributed to influxes of nitrogen from outside sources. The average nitrate concentration fell however within WHO limit and was not significantly different across the sampled stations. The range of phosphate obtained was 0.01mg/l-0.53mg/l and was not significantly different across the stations. In 2007, Omoigberale and Ogbeibu reported higher values of 0.28mg/l to 3.52mg/l from Osse River and Anyanwu reported 0.10mg/l to 1.44mg/l in 2012. The reason for the decreased Phosphate value, compared to other aquatic systems may be due to the heterotrophic uptake by micro-organisms, sediment adsorption, as well as removal by the currents (Anyanwu, 2012). Dissolved oxygen, which is a measure of the amount of oxygen that is freely available in water, is essential for sustaining aquatic life in any ecosystem. The average value (4.27mg/l) obtained in this study is similar to that obtained in other tropical rivers (Imoobe and

Adeyinka, 2010; Anyamwu; 2012) from Ogba river. This value is slightly less than the permissible limit (5mg/l) necessary to sustain aquatic life, an indication that the water quality was starting to deteriorate.

The Biological Oxygen Demand (BOD) is a measurement of the oxygen requirement of biodegradable organic wastes in water. Values less than 1.2mg/l are considered clean, 3mg/l fairly clean, 5mg/l doubtful and 10mg/l serious (Rim-Rukeh *et al.*, 2006), thus high B.O.D is an indication of poor water quality. The average biochemical oxygen demand obtained in the study area was 1.87mg/l and there was no significant difference across the stations, hence indicates the water is categorized between fairly clean and clean. Alkalinity values ranged between 6.0mg/l to 48.0mg/l in this study. The average value did not exceed WHO limit. The value in this study is lower than those obtained in other water bodies in Nigeria; Adebisi (1981), recorded 77.9mg/l for Ogun river, Ogbeibu and Victor (1995) recorded a range of 14.7mg/l – 50.7mg/l for Itawogba stream system, Port-Harcourt. The total alkalinity of a water body is a reflection of its carbonate and bicarbonate profiles. However, low alkalinity values are indications of low carbonate and bicarbonate ions in the water, a reflection of the absence of limestone in the drainage basin (Imoobe and Oboh, 2003). Iron was the highest occurring heavy metal in the surface water of Osse River with an average mean of 0.64mg/l which is lesser than WHO limit. This was expected because it has been reported that Iron occurs at high concentration in Nigeria soil (Asaolu *et al.*, 1997; Asaolu and Olafe, 2004). Similarly, Eddy and Ukpong (2002) reported that Iron had the highest concentration in upper Calabar River. The value obtained in this study is lower than that obtained in Ogba River (Anyanwu, 2012) and Itaogbolvin Ondo (Adefemi and Awokunmi, 2010). The Zinc concentration in the surface water of Osse River had an average mean of 0.23mg/l which is less than the WHO limit. The average value was significantly higher than that in Ogba River Benin City (Anyanwu, 2012) and lower than that of River Ganga (0.37mg/l) (Kar *et al.*, 2008) Ona River (3.2mg/l) (Adefemi and Awokunmi, 2010) and Jabi Lake (4.72 mg/l) (Umar and Ebong, 2013). The Average Chromium concentration found in Osse River was (0.13mg/l) which was greater than WHO limit and was not significantly different across the sampled stations. This value was higher than that reported by Ogbeibu and Oribhabor (2009) on the assessment of heavy metals on Niger Delta creek (0.025mg/l) and also that reported by Begum *et al.* (2009) (0.0025mg/l) in Madivala lake. Adefemi and Awokunmi (2010) reported an average Chromium

concentration of 0.2mg/l in Itaogbolu area of Ondo state.

Table 2: Mean \pm SE values of investigated physical and chemical characteristics of Gelegele River (September 2014 to June 2015)

Parameters	Station1 Mean \pm SE (Min, Max)	Station2 Mean \pm SE (Min, Max)	Station3 Mean \pm SE (Min, Max)	Station4 Mean \pm SE (Min, Max)	P-Value	WHO
pH	6.96 \pm 0.11 (6.3, 7.3)	6.87 \pm 0.12 (6.2, 7.5)	6.83 \pm 0.10 (6.2, 7.2)	6.86 \pm 0.12 (6.2, 7.3)	P>0.05	6.5-9.5
Suspended Solid	11 \pm 1.78 (4, 25)	14 \pm 4.12 (7, 48)	10 \pm 1.83 (6, 24)	9.5 \pm 1.85 (5, 24)	p>0.05	3
Turbidity(NTU)	17 \pm 2.73 (7, 38)	16 \pm 3.52 (7, 39)	16 \pm 2.75 (8, 37)	17 \pm 3.22 (7, 38)	P>0.05	5
Conductivity(μ S/cm)	59 \pm 12.05 (20, 110)	46 \pm 8.19 (20, 90)	45 \pm 7.92 (20, 90)	45 \pm 7.83 (20, 90)	p>0.05	1200
Alkalinity	19 \pm 4.10 (8, 36)	19 \pm 3.46 (10, 38)	21 \pm 5.39 (6, 48)	17 \pm 3.29 (8, 34)	p>0.05	100
Chloride	10 \pm 0.80 (7.1, 14.1)	13 \pm 1.65 (7.1, 21.2)	12 \pm 1.16 (8.4, 17.7)	11 \pm 1.37 (7.1, 17.7)	p>0.05	250
Hardness	19 \pm 2.81 (8, 32)	19 \pm 3.55 (10, 42)	22 \pm 4.67 (10, 56)	17 \pm 2.74 (8, 32)	p>0.05	500
Phosphate	0.2 \pm 0.04 (0.06, 0.39)	0.3 \pm 0.05 (0.01, 0.53)	0.2 \pm 0.04 (0.02, 0.34)	0.2 \pm 0.04 (0.05, 0.35)	p>0.05	0.2
Sulphate	14.0 \pm 2.15 (5, 25)	18 \pm 3.06 (5, 33)	15 \pm 2.0 (6, 25)	13 \pm 1.15 (8, 17)	p>0.05	500
Nitrate	4.0 \pm 0.7 (1.4, 6.6)	3.4 \pm 0.6 (1.6, 8.0)	3.1 \pm 0.7 (1.4, 9.3)	3.3 \pm 0.7 (1.2, 9.1)	p>0.05	10
DO	4.3 \pm 0.7 (2.2, 8.4)	4.2 \pm 0.7 (2.0, 7.6)	4.1 \pm 0.6 (2.0, 6.7)	4.5 \pm 0.7 (2.1, 7.8)	P>0.05	-
BOD	1.8 \pm 0.3 (0.6, 3.6)	2.1 \pm 0.46 (0.7, 5.1)	1.6 \pm 0.3 (0.4, 3.3)	2.0 \pm 0.3 (0.7, 5.8)	P>0.05	-
Iron	0.8 \pm 0.12ab (0.1, 1.4)	0.5 \pm 0.08a (0.1, 0.9)	1.0 \pm 0.17c (0.2, 1.8)	0.4 \pm 0.04a (0.2, 0.6)	**P<0.01	3
Zinc	0.2 \pm 0.04 (0.1, 0.41)	0.2 \pm 0.06 (0, 0.58)	0.4 \pm 0.11 (0, 0.93)	0.1 \pm 0.05 (0, 0.41)	P>0.05	3
Chromium	0.2 \pm 0.08 (0, 0.65)	0.1 \pm 0.05 (0, 0.36)	0.1 \pm 0.04 (0.01, 0.33)	0.1 \pm 0.05 (0, 0.38)	P>0.05	0.05
Cadmium	0.0001 \pm 0.0001a (0, 0.001)	0.001 \pm 0.001a (0, 0.01)	0.0157 \pm 0.005b (0, 0.041)	0.0006 \pm 0.0005a (0, 0.005)	**P<0.01	0.003
Lead	0.016 \pm 0.007 (0, 0.05)	0.025 \pm 0.011 (0, 0.09)	0.034 \pm 0.010 (0, 0.09)	0.059 \pm 0.031 (0, 0.26)	P>0.05	0.01
Manganese	0.038 \pm 0.010b (0.007, 0.09)	0.014 \pm 0.001a (0.009, 0.02)	0.039 \pm 0.008b (0.012, 0.082)	0.014 \pm 0.003a (0, 0.034)	*P<0.05	0.4
Copper	0.007 \pm 0.002a (0, 0.018)	0.010 \pm 0.003ab (0, 0.026)	0.025 \pm 0.007b (0.001, 0.059)	0.010 \pm 0.002ab (0.001, 0.017)	**P<0.01	2
Nickel	0.102 \pm 0.042 (0, 0.31)	0.145 \pm 0.062 (0, 0.49)	0.167 \pm 0.063 (0, 0.45)	0.104 \pm 0.051 (0, 0.34)	P>0.05	0.02
Vanadium	0.003 \pm 0.001 (0, 0.013)	0.004 \pm 0.002 (0, 0.014)	0.010 \pm 0.004 (0, 0.027)	0.001 \pm 0.0007 (0, 0.0006)	P>0.05	0.01

The average Cadmium concentration in this study was 0.004mg/l and was greater than WHO limit and was highly significantly different across the sampled stations with station 3 having the highest value. This value obtained from this study was slightly higher than the Cadmium concentration (0.0012mg/l) obtained in Avsar River turkey (Ozturk *et al.*, 2009) and lower than the value obtained from the Niger Delta creek (0.028mg/l) and Jabi lake (0.28mg/l) (Ogbeibu and Oribhabor, 2009; Umar and Ebong 2013). The mean Lead concentration (0.034mg/l) of the surface water is higher than the WHO limit but not significantly different across the stations. The lead concentration obtained in this study is similar to the findings of Omoigberale and Ikponmwosa-Eweka (2010) (0.023mg/l) in their study of Ovia river. Nickel concentration of surface water had a mean value of 0.130mg/l which was higher than WHO limit and

showed no significant difference across the stations. The average concentration obtained is in contrast to below the detection limits (BDL) observed by Ayas *et al.* (2007), Ozturk *et al.* (2009), Nongbri and Syiem (2012). This result was similar to that obtained by Adefemi and Awokunmi (2010) (0.1mg/l) in Itaogbolu area of Ondo state. Mean Manganese concentration in this study was 0.026mg/l which was lesser than the WHO limit. This value was lower than the value obtained by Anyanwu (2012) in Ogba River, Benin City. The mean copper concentration (0.013mg/l) of Osse River as reported in this study was highly significant and falls within WHO limit. The concentration could be due to pollutant residual of the boating activities within the river.

Water Quality Index: The concentrations of the various considered physical and chemical parameters

that have established regulatory values were used to determine the WQI values of the sampled stations. The Water Quality Index of all sampled stations within the study area is represented in Table 3. The excellent water quality (8.03 – 9.07) recorded for Osse River suggests that the water is suitable for drinking and use for other domestic purposes. All four stations had excellent water quality.

Table 3: Summary of Water Quality Index (WQI) values at the Osse River sampling stations

Station	WQI	Water quality
Station 1	9.067605	Excellent
Station 2	8.704997	Excellent
Station 3	8.733481	Excellent
Station 4	8.028244	Excellent

Etim *et al.* (2013) reported higher WQI values (55.05 – 84.94) for selected streams in the Niger Delta region, and this indicates poor water quality as a result of crude oil exploration within this region. A fairly higher WQI value (11.24 - 16.15) was recorded by Oboh and Agbala (2017) for Siluko River in Edo State, Nigeria.

Conclusion: The concentration of metals in the samples collected from Osse River indicates that the metallic ions are within background concentration level in the water body. The mean Dissolved Oxygen and Biological Oxygen Demand obtained from this study indicate the water from the study area is rated between fairly clean and clean. The Water Quality Index indicates excellent water quality. Thus, the water is presently suitable for domestic use, but increase anthropogenic activities along the river course will result in water quality deterioration in the nearest future.

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