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Quality Assessment of Physico-Chemical Characteristics of Okura River, Kogi State, Nigeria

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ABSTRACT

Physico-chemical parameters have been used to monitor water quality of about 34 km stretch of the catchment area of River Okura. Water samples collected from River Okura at Oji-Aji, Igodo, Ogodu, Okura and Ofe-Jiji have been subjected to physical and chemical analyses required for water quality evaluation. The water samples have pH value of 7.59, on the average. This indicates that, the water is slightly alkali. Measured Electrical Conductivity ranges from 0.02µS/cm at the river source in Oji-Aji to 0.05µS/cm in Ofe-Jiji. This low concentration implies low ionic content of the river water. The concentrations of Total Solids, Turbidity and Salinity increases down-stream from 22.60mg/l, 6.45mg/l and 0.23mg/l in Oji-Aji to 126mg/l, 9.08mg/l and 0.62mg/l, respectively in Ofe-Jiji. This indicates some level of pollution in the water. Cationic components of Water samples indicate, $Ca^{2+} > Na^{+} > K^{+} > Mg^{2+}$ while anionic component is in the order of; $HCO_3^{-} > Cl^{-} > SO_4^{2-} > NO_3^{-} > PO_4^{3-} > CO_3^{2-}$. The concentrations are within the permissible limits of World Health Organization and Standard Organization of Nigeria guidelines for drinking water.

Keywords: *Water Quality, Okura River.*

I. INTRODUCTION

Okura River is the principal source of water for people within its catchment area. As human population around the river continues to grow, there is a consequent increase in demand of water for domestic and agricultural uses in the area. There has also been an increase in the impairment of environmental components through human and animal activities which could pollute or contaminate the river. Therefore, quality assessment of River Okura, which is the tool for its effective use and management become essential. Limits to good qualitative water supply in an area also places limit on the sustainable population of the area.

The study area is situated between latitudes 7^0 21' N and 7^0 38' N and longitudes 7^0 07' E and 7^0 34'E and covering part of Omala and Dekina Local Government Areas of Kogi State, Nigeria and falls within the humid tropical rain forest of Nigeria. It is part of sheets 248 and 268. The mean annual rainfall is well over 200mm (Ogbonna *et al*, 2006). The Ofe-Jiji and Okura village locations are on the Anyigba – Ankpa paved road, while the locations at Ogodu, Igodo and Oji-Aji are accessible through the Anyigba–Egume –Ofogu paved road. The elevation above sea level of the River ranges from 367m (± 5m) at its source in Oji-Aji to 203m (± 5m) in Ofe-Jiji. The river is perennial and parallel in pattern to Ofu and Imabolo rivers which are close to the study area. Okura River joined Imabolo River in Egabada (Kogi State) and further flow southwards before joining the Ofu River and the 'three-in-one' river empties into the famous Anambra River (Anambra State).

The vegetation of the study area falls within the guinea savannah belt and consists essentially of short to tall trees which reflects degradation by man through bush burning, cutting and cultivation (Ifatimehin & Musa, 2008).

Geologically, the study area falls within the Anambra sedimentary basin which is Cretaceous in age (Reyment, 1965). It is bounded to the Northwest by Bida / Nupe Basin, to the North by North central highland, consisting of the basement complex rocks of Nigeria, to the North-East by Benue trough, to the south by Niger Delta Basin and to the East by Abakaliki fold belt (Anticline). According to Reyment (1965), Anambra Basin was a plat-form that is only thinly covered by older sediment during the Albian-Santonian epoch of the Cretaceous. The Post Maastrichtian folding movement affected all the sediments, which were less intensified than the Santonian episode. The later sediment in Anambra Basin were sourced from the Abakaliki uplift, Cameroon basement granite and Oban massif to the South-East (Reyment, 1965). Anambra Basin is a nearly triangular-shaped embayment, covering an area of about 30,000 square kilometers. It stretches from the area just south of the confluence of the Rivers Niger and Benue across localities like Ankpa, Anyigba, Idah, Nsukka, Onitsha and Awka (Reyment, 1965).

In term of stratigraphic sequence, Ajali Formation which is about 330m thick and the most aquiferus Formation in the Anambra sedimentary Basin is underlain by Mamu and Nkporo Formations. Interestingly, River Okura's source (Oji-Aji) is at the North – East boundary of Ajali Formation and the

immediate underlying Mamu Formation. Ajali Formation consists of thick, friable, poorly sorted sandstone, typically white in colour but sometimes iron-stained. Banding of coarse and fine layers is displayed when closely observed (Obaje, 2009).

The people of the area are peasant farmers and civil servants who use the available land for farming and the River water for washing, drinking and other domestic works. The few hand dug wells in some parts of the localities are due to the high water table. This paper examines the physico-chemical characteristic of River Okura at five locations downstream, starting from its source with a view to determining its potability for human consumption.

II. MATERIALS AND METHODS

A total of thirty (30) water samples of Okura River were collected at five (5) different locations, starting from Oji-Aji (source), Igodo, Ogodu, Okura and Ofe-Jiji (Fig. 2). At each location, six (6) sets of water samples were obtained. Sampling stations were chosen on the basis of land-use as well as water-use proximity to sources of pollution such as agriculture and domestics. The samples were collected in new plastic bottles which had been thoroughly washed and sterilized to avoid contamination. At each location, the sample bottles were rinsed with the water samples before collection. About 2.0 litres of six (6) samples were collected at each location which was from the sides and the approximate width of the river. At Ofe-jiji where the river is dammed, sampling was sequential: surface, about 5 meter depth and about 8 meters depth. Unstable water parameters such as Temperature, pH, Total Dissolved Solid, Electrical Conductivity and Dissolved Oxygen were measured in-situ using Thermometer, Hanna HI9813 Grochek (which measures pH, Total Dissolved Solids and Electrical Conductivity) and Dissolved Oxygen meter, respectively. The remaining water samples were protected from heat, taken to the laboratory and stored in the refrigerator at 4^oC to avoid ionization. Bulk Scientific - Flame Atomic Absorption Spectrophotometer (A.A.S), Model 210 VGP was used to determine the concentrations of the following cations: Cu^{2+}, Ca^{2+}, Mg^{+}, Na^{+}, K^{+}, Pb^{+}, Fe^{2+} and Zn^{2+} at the Department of Earth Sciences of Kogi State University, Anyigba. Determinations of concentration of nitrate was carried out using Anderson and Ingram method of 1989, sulphate was by Turbid-metric method of 1974, chloride by Mohr's method of 1988, carbonate and bicarbonate by the provisional method of Barnes *et al*, 1981 and phosphate by Molybdate blue method of O'Neil and Mame of 1999, using Genesys 20 Spectrophotometer and standard titration apparatus. Also, for statistical analysis of data, ANOVA was employed to establish the variation in the concentration of physical and chemical parameters of the river.

III. RESULTS PRESENTATION

The result of physical and chemical parameters of Okura River within the study area is shown in table 9. The pH ranged from 7.50 to 7.75 with an average of 7.59. The temperature level of the water samples is 27.60^oC on the average. Conductivity of the river ranged from 0.02µS/cm in Oji-Aji to 0.13 µS/cm in Ofe-Jiji. The Total Dissolved Solid (TDS) follows the same pattern as conductivity: it varies from 19.50mg/l in water samples from Oji-Aji to 97.80mg/l in samples from Ofe-Jiji with a mean concentration of 35.84mg/l. The measured concentration of Mg^{2+} has concentration values that ranges from 0.09 mg/l to 0.59mg/l measured from Okura town and Ofe-Jiji locations water samples, respectively. The measured concentration of K^{+} ranges from 0.13mg/l in Ogodu location water samples to 0.34mg/l in Ofe-Jiji location water samples. The concentration of Na^{+} ranges between 0.33mg/l in Igodo and 0.49mg/l in Ofe-Jiji. Measured concentration of Fe^{2+} in the water samples range from 0.12mg/l in Oji-Aji water samples to 0.21mg/l in Ofe-Jiji water samples. Heavy metals (Cu, Pb and Cd) concentrations in the river were generally low and below detection limit in most cases (Table 2). Among the water samples, Oji-Aji, Igodo, Ogodu and Okura town locations contains cations with a concentration trend in which $Ca^{2+} > Na^{+} > K^{+} > Mg^{2+}$ (Table 2 and Fig. 3). The results obtained from the determinations of Nitrate, sulphate, chloride, carbonate, bicarbonate and phosphate in water samples from the study area and the cationic concentration of the river are shown in table 2.

IV. DISCUSSION

Physical Characteristics

The pH of River Okura in the study area is 7.59 on the average. This value conforms to most fresh water pH (Chapman, 1992) and indicates that the water is slightly alkaline. Strongly acidic or strongly alkaline water are hazardous to humans, animals and plants because, such water burns skin, tissue and organs. Also, Water of very low pH value may increase solubility of toxic metals in waters which may eventually lead to death of fish and other aquatic animals (O' Neill, 1985). The temperature value of the river is 27.60^oC, according to Ige *et al.*, 2008; this temperature value relatively keeps ionization and dissolution at low levels. High water temperature promotes euthrophication and leads to reduction of dissolved oxygen content of the water which might ultimately lead to death of fish and other aquatic organisms (O'Neill, 1995). Also, chemical reactions are enhanced by a rise in temperatures, enabling the water to dissolve more substances faster. Much quantity of undesired substances may promote reactions leading to the formation of secondary pollutants. The low electrical conductivity (0.05µS/cm) of the river implies that, its ionic contents are low as reported by Lorch, 1987. High TDS in water may impart salty taste to the water and such water becomes unsuitable for drinking, irrigation and industrial usages (O'Neill 1995). The Total Solids (TS) and Turbidity contents of the river are low. High Turbidity disturbs light transmitting quality of water thereby lowering biological productivity of aquatic organisms. Moreover the suspended matter may contain toxic substances (such as trace metal pellets) which may result in physical smothering of aquatic organisms (Jackson *et al*. 1989). The concentrations of the physical parameters fall within the permissible level of Standard Organization of Nigeria (SON, 2007) and World Health Organization (WHO, 2011) guidelines for drinking water (Table 3).

Cationic Components

The results of chemical analysis of the water samples shows that, Ca^{2+} has concentration values ranging between 0.07mg/l to 1.52mg/l. The lowest Ca^{2+} value was recorded in samples from Oji-Aji while the highest value was measured from samples from Ofe-Jiji. The Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+} measured concentrations in the water samples from Okura River all fall within the permissible level of Standard Organization of Nigeria (SON, 2007) and World Health Organization (WHO, 2011) guidelines for drinking water (Table 3). The average concentration of Fe^{2+} in the river within the study area is 0.16mg/l which is within the permissible limit prescribed by both WHO (2011) and SON (2007) of 0.3mg/l. Iron in water up to 0.3ppm imparts objectionable colours and taste to the water and causes staining in laundry and metal pipes scaling (Alloway and Ayres, 1993).

Among the water samples, Oji-Aji, Igodo, Ogodu and Okura town locations contains cations with a concentration trend in which $Ca^{2+} > Na^{+} > K^{+} > Mg^{2+}$ (Table 2 and Fig. 3). This composition is reflective of water derived from source rock that is rich in feldspars (Ige *et al*., 2008). Figure 3 shows that, the concentrations of the Alkali metals slightly increase downstream.

Anionic Components

Within the study area of Okura River, HCO_3^- has the highest anionic concentration of 2.6mg/l on the average. Cl^- concentration varies from 0.67mg/l in water samples from Ogodu to 1.66mg/l in Ofe-Jiji samples with an average concentration of 0.96 ppm. However, they conforms to World Health Organization (WHO) of 2011 guidelines and Standards Organization of Nigeria (SON) of 2007, for drinking water quality which are 250 mg/l and 100 mg/l respectively, (Table 2). Nitrate content in River Okura follows ranges from 0.02mg/l in Oji-Aji location to 1.29mg/l in Ofe-Jiji sample point with an average of 0.36mg/l. Higher level of nitrate concentration in Ofe-Jiji water samples compare to those of Oji-Aji, Igodo, Ogodu and Okura Town locations could be an indication of minute level of anthropogenic pollution of the river dam. Consumption of water containing nitrate above the WHO (2011) guideline level of 70 ppm in drinking water by infants up to six months old, produce a 'blue baby' condition called methemoglobinemia, resulting from reduction of nitrate to nitrite by certain bacteria in the body of the infant (O' Neill, 1995). Average concentration of sulphate in the river is 0.55ppm, which means that the water is not laxative (Jackson *et al.*, 1989). In natural waters sulphate concentrations usually vary between less than 2 to 80ppm, though higher values may be obtained if gypsum is present in the soil (Chapman, 1992). Phosphate contents in the water samples ranges from 0.21mg/l in Oji-Aji to 0.44mg/l in Ofe-Jiji locations. These values are very low and imply that, pollution from industrial and agricultural sources such as detergents and phosphate fertilizers respectively are insignificant if any. Generally, the concentration of anions increases slightly downstream, except at Igodo where the concentration of chloride (Cl-) increased significantly. At Ofe-Jiji where the river is dammed, the concentrations of anions are far higher compared to those of previous locations (Fig. 4).

V. CONCLUSIONS

Thirty (30) water samples collected from River Okura at five (5) locations: Oji-Aji, Igodo, Ogodu, Okura town and Ofe-Jiji have been subjected to physical and chemical analyses required for water quality evaluation. The water samples have measured pH in the range of 7.50 to 7.53 with a mean value of 7.53 which indicate that, the water in the study area is slightly alkali. Electrical conductivity of the analysed water samples range from 0.02 µS/cm to 0.013 µS/cm with a mean value of 0.05 µS/cm which implies that, the ionic content of the river is low. The total dissolved solid (TDS) vary from 19.50 mg/l in water samples from Oji-Aji location flowing and interacting with domestic and possibly agriculture components through Igodo, Ogodu and Okura-town communities to 97.80 mg/l in Ofe-Jiji water sample. Similarly, the concentrations of total solid, turbidity and salinity of the river increases downstream from 22.60 mg/l, 6.45 mg/l and 0.23 mg/l in Oji-Aji (source) to 126mg/l, 9.08mg/l and 0.62mg/l, respectively, in Ofe-Jiji. This indicates some level of pollution. Water samples in all the locations indicate cationic concentration in which, $Ca^{2+} > (Na^{+} + K^{+}) > Mg^{2+}$ and anionic component is in the order of; $HCO_3^- > Cl^- > SO_4^{2-} > NO_3^- > PO_3^- > CO_3^-$. The concentration of these parameters increases downstream. At Ofe-Jiji where the river is dammed, the concentration of anions is far higher compared to those of previous locations. The concentration of physical and chemical parameters of the river falls within the permissible level of World Health Organization (WHO, 2011) and Standard Organization of Nigeria (SON, 2007) guidelines for drinking water. This makes River Okura potable based on the concentrations of the physico-chemical parameters, although, the presence of anions such as nitrate and sulphate indicates certain levels of unwanted substances in the river. Therefore, since the chemistry of water is dynamic and time dependent, periodic surveillance on the pollution and contamination status of the river is recommended.

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Table 1: Mean and Standard Deviation of Physical Parameters of Water from Okura River

	Oji-Aji	Igodo	Ogodu	Okura Town	Ofe-Jiji
parameters	n = 6	n = 6	n = 6	n = 6	n = 6
Temp. ^{0}C	27.40 ±0.48	27.60 ±0.49	27.90 ±0.69	27.45 ±0.59	27.66 ±0.25
pH	7.50 ±0.90	7.55 ±0.93	7.60 ±0.98	7.75 ±0.96	7.53 ±0.77
EC (µS/cm)	0.02 ±0.01	0.03 ±0.01	0.03 ±0.01	0.03 ±0.01	0.13 ±0.08
TDS (mg/l)	19.50 ±7.33	19.80 ±7.19	20.30 ±6.71	21.80 ±6.40	97.80 ±41.5
SS (mg/l)	2.43 ±2.03	3.63 ±0.99	3.79 ±3.21	3.83 ±1.40	28.67 ±9.13
TS (mg/l)	22.60 ±6.01	23.38 ±6.58	24.12 ±5.06	25.66 ±5.64	126.50 ±33.31
Turbidity (mg/l)	6.45 ±1.15	6.41 ±0.90	6.44 ±1.19	6.65 ±1.70	9.08 ±3.04
Salinity (mg/l)	0.23 ±0.05	0.26 ±0.29	0.30 ±0.10	0.69 ±0.07	0.62 ±0.26
DO (mg/l)	7.76 ±0.08	7.68 ±0.16	7.63 ±0.15	7.55 ±0.12	7.08 ±0.60

n…….the number of sample from location.

Table 2: Mean and Standard Deviation of Physical Parameters of Water from Okura River

	Oji-Aji	Igodo	Ogodu	Okura Town	Ofe-Jiji
parameters	n = 6	n = 6	n = 6	n = 6	n = 6
Na (mg/l)	0.34 ±0.06	0.33 ±0.08	0.39 ±0.20	0.41 ±0.06	0.49 ±0.02
K (mg/l)	0.22 ±0.04	0.16 ±0.06	0.13 ±0.07	0.18 ±0.05	0.34 ±0.03
Ca (mg/l)	0.74 ±0.12	0.91 ±0.07	1.01 ±0.22	1.02 ±0.44	1.52 ±0.05
Mg (mg/l)	0.14 ±0.05	0.11 ±0.04	0.12 ±0.04	0.09 ±0.03	0.59 ±0.00
Fe (mg/l)	0.12 ±0.01	0.13 ±0.01	0.18 ±0.01	0.18 ±0.1	0.21 ±0.01
Zn (mg/l)	0.09 ±0.03	0.07 ±0.55	0.11 ±0.02	0.14 ±0.02	0.31 ±0.07
Cu (mg/l)	0.001 ±0.00	BDL 0.00	0.001 ±0.00	0.001 ±0.00	0.006 ±0.00
Pb (mg/l)	BDL	0.002 ±0.00	0.001 ±0.00	0.005 ±0.00	0.016 ±0.01
Cd (mg/l)	BDL	BDL	BDL	0.001 ±0.00	0.001 ±0.00
NO_3^- (mg/l)	0.017 ±0.01	0.033 ±0.00	0.03 ±0.00	0.410 ±0.01	1.285 ±1.36
SO_4^{2-} (mg/l)	0.023 ±0.00	0.020 ±0.00	0.04 ±0.01	0.046 ±0.00	2.665 ±2.88
Cl^- (mg/l)	0.590 ±0.08	1.103 ±0.16	0.67 ±0.13	0.798 ±0.09	1.662 ±0.64
CO_3^- (mg/l)	0.019 ±0.01	0.026 ±0.00	0.03 ±0.00	0.176 ±0.15	0.298 ±0.29
PO_4^{3--}	0.211 ±0.02	0.340 ±0.06	0.305 ±0.02	0.380 ±0.31	0.435 ±0.03
HCO_3^-	2.00 ±0.01	2.51 ±0.01	2.62 ±0.01	2.60 ±0.31	4.1 ±0.11

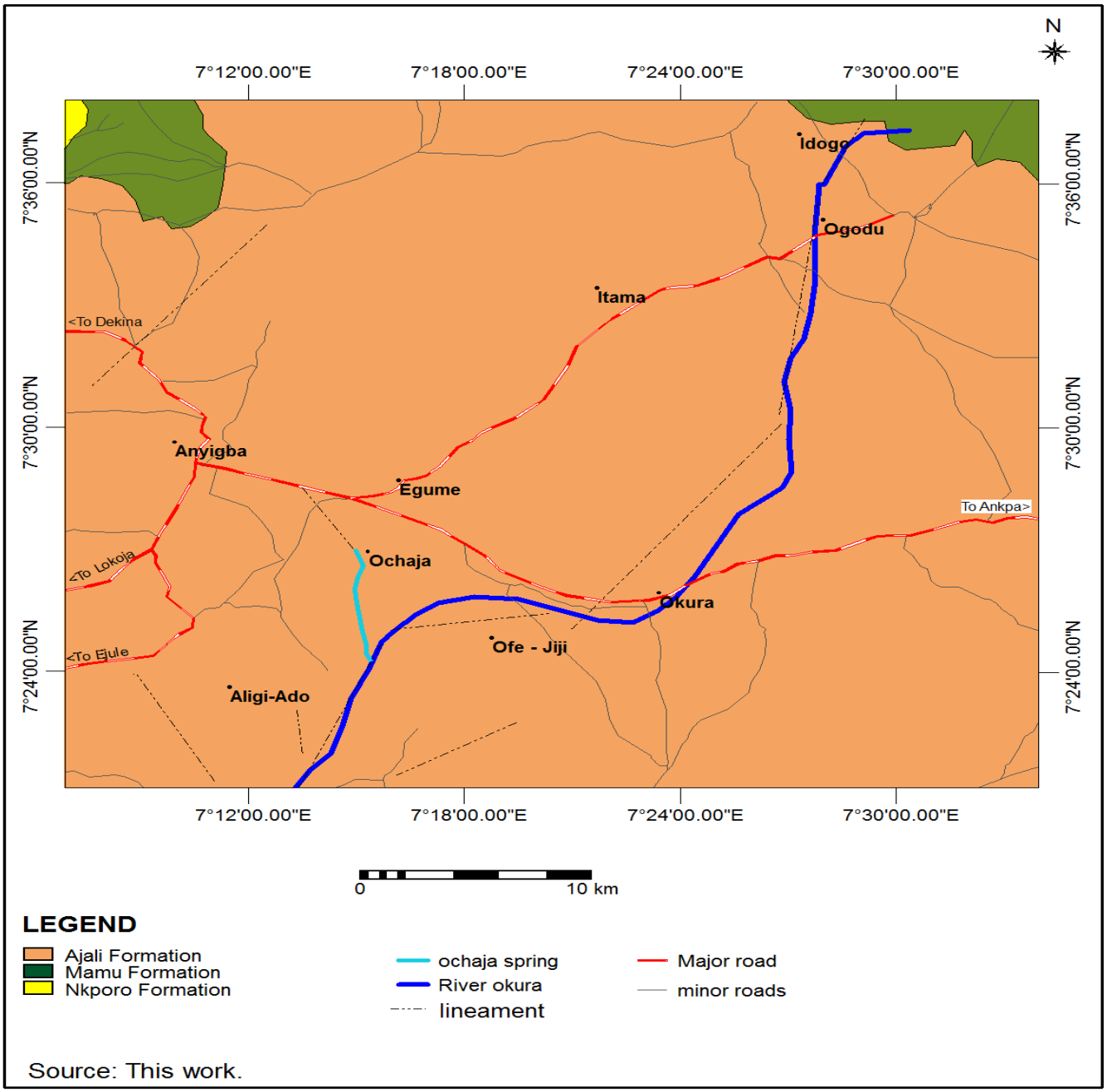
n …….the number of sample from location.
BDL …. Below Detection Limit.

Table 3: Concentration of Physico-Chemical Parameters of Water in the Study Area and Water Quality Standards

	Oji-Aji	Igodo	Ogodu	Okura Town	Ofe-Jiji	Average	WHO(2011) Water Standards	SON(2007) Water Standard
parameters	n = 6	n = 6	n = 6	n = 6	n = 6	n = 30	Maximum permissible level	Maximum permitted level
Temp. ^{0}C	27.40	27.60	27.90	27.45	27.66	27.60		Ambient
pH	7.50	7.55	7.60	7.75	7.53	7.59	6.5 - 8.5	6.5 - 8.5
EC (µS/cm)	0.02	0.03	0.03	0.03	0.13	0.05		1000
TDS (mg/l)	19.50	19.80	20.30	21.80	97.80	35.84	1500	1500
SS (mg/l)	2.43	3.63	3.79	3.83	28.67	8.47		
TS (mg/l)	22.60	23.38	24.12	25.66	126.50	44.45		
Turbidity (mg/l)	6.45	6.41	6.44	6.65	9.08	7.01		
Salinity (mg/l)	0.23	0.26	0.30	0.69	0.62	0.42		
DO (mg/l)	7.76	7.68	7.63	7.55	7.08	7.54		
Na (mg/l)	0.34	0.33	0.39	0.41	0.49	0.39	200	200
K (mg/l)	0.22	0.16	0.13	0.18	0.34	0.21		
Ca (mg/l)	0.74	0.91	1.01	1.02	1.52	1.04	200	200
Mg (mg/l)	0.14	0.11	0.12	0.09	0.59	0.21	150	150
Fe (mg/l)	0.12	0.13	0.18	0.18	0.21	0.16	0.3	0.3
Zn (mg/l)	0.09	0.07	0.11	0.14	0.31	0.14	4.00	3.00
Cu (mg/l)	0.001	BDL	0.001	0.001	0.006	BDL	2.00	1.0
Pb (mg/l)	BDL	0.002	0.001	0.005	0.016	BDL	0.05	0.01
Cd (mg/l)	BDL	BDL	BDL	0.001	0.001	BDL		0.003
NO_3^- (mg/l)	0.017	0.033	0.03	0.410	1.285	0.36	70	50-70
SO_4^{2-} (mg/l)	0.023	0.020	0.04	0.046	2.665	0.56	250	100
Cl^- (mg/l)	0.590	1.103	0.67	0.798	1.662	0.96	400	300
CO_3^{2-} (mg/l)	0.019	0.026	0.03	0.176	0.298	0.11		400
PO_4^{3-}	0.211	0.340	0.305	0.380	0.435	0.33		
HCO_3^-	2.00	2.51	2.62	2.60	4.1	2.67		600

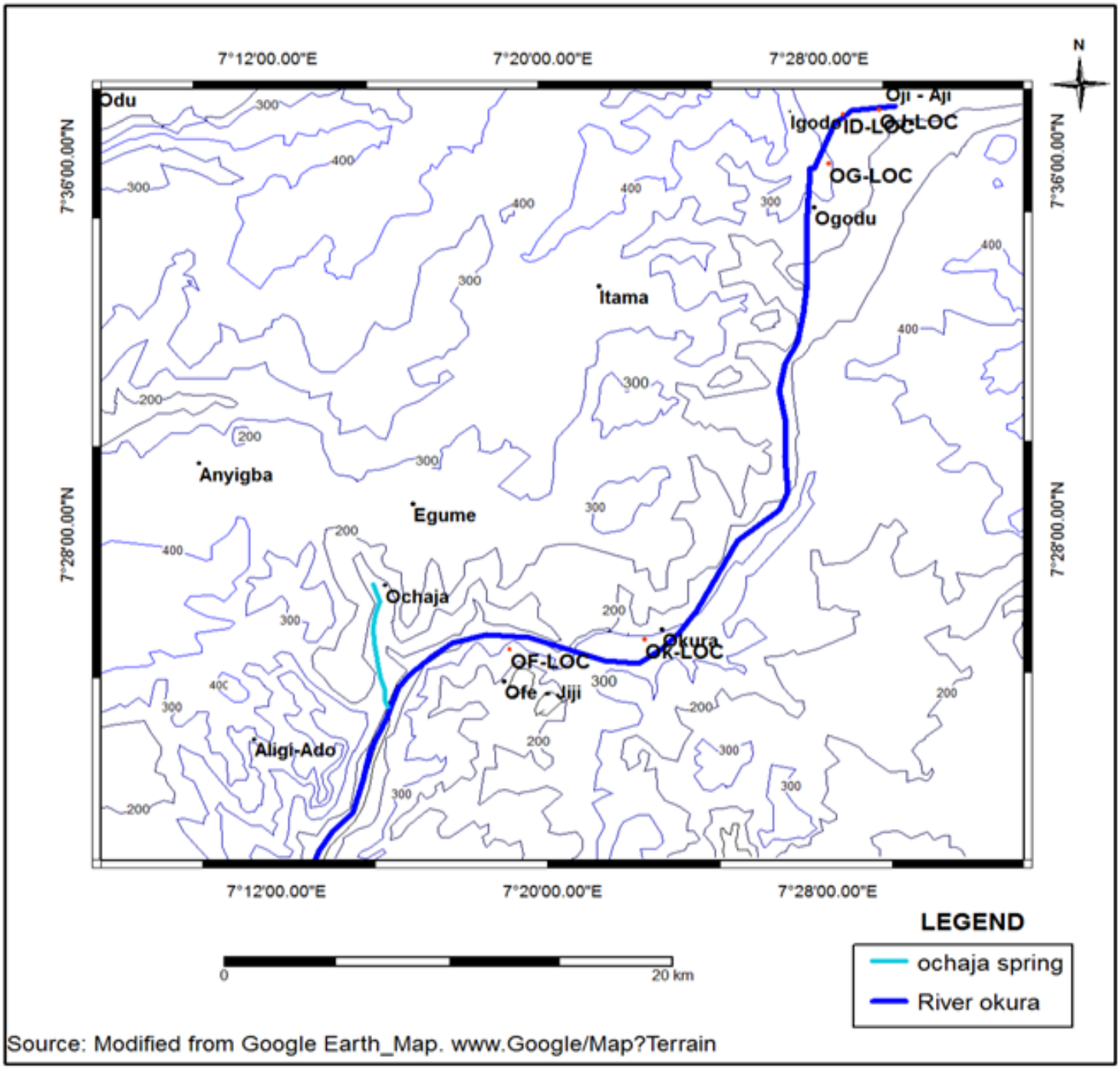
Note: Guideline values have not been established for constituents influencing water parameters that have no direct link to adverse health impacts.

- BDL…….. Below Detection Limit.
- SON….. Standard Organization of Nigeria.
- WHO ….World Health organization.



Source: Modified from Google Earth/Map.

Figure 1: Geological Map of Part of Okura River Catchment Area



OJ - LOC.....Oji-Aji Sample Location
ID - LOC.....Igodo Sample Location
OG - LOC.....Ogodu Sample location
OK - LOC.....Okura Sample Location
OF - LOC.....Ofe-Jiji Sample Location

Figure 2: Map Showing Sample Station

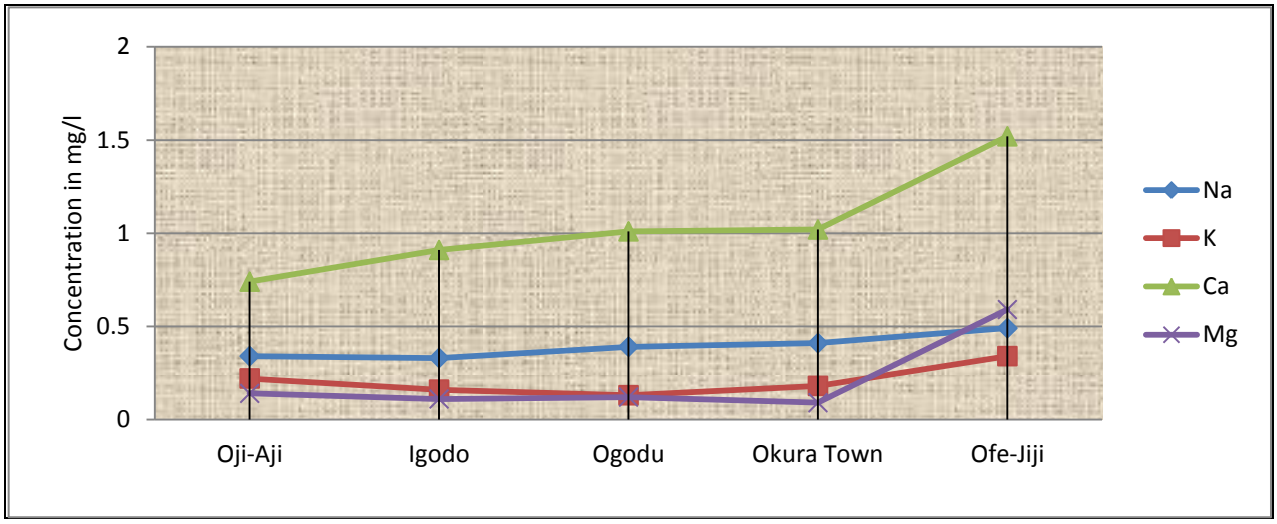


Figure 3: Concentration Trend of Alkali Metals in Okura River