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Research Paper

Impact of urban activities on the physicochemical characteristics and metals contents of the Sapele section of the Benin-Ethiope river system, Delta State, Nigeria.

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ABSTRACT : *This study focuses on the quality of the river water in Sapele section of the Benin-Ethiope river system as impacted by the activities taken place in the metropolis, using metals contents and physicochemical properties determined by standard methods as indices of evaluation. The mean values of the determined parameters were: temperature (26.11±0.30^{o}C), pH (5.90±0.11), Dissolved Oxygen (6.54±0.49mg/L), Biochemical Oxygen Demand (1.66±0.30 mg/L), Chemical Oxygen Demand (5.73±0.75 mg/L), Total Dissolved Solids (11.82±3.7 mg/L), Total Suspended Solids (26.00±5.66 mg/L), Conductivity (23.64±7.3µS/cm), Turbidity (7.9±0.77 NTU), Oil and Gas (1.73±0.60 mg/L), and Total Hardness (1.13±0.26mgCaCO$_3$/L). Others are: Chlorides (6.57±1.26 mg/L), Nitrates (4.85±1.82 mg/L), Nitrites (0.15±0.11 mg/L), Phosphates (1.88±0.60 mg/L), Bicarbonates (4.13±1.60 mg/L), and Sulphates (1.50±0.38 mg/L). The concentrations of Ca and Mg ions accounting for total hardness were 0.243±0.08 mg/L and 0.126±0.02 mg/L respectively. The average values for the other ions were: Na (0.65±0.04 mg/L), K (0.30±0.07 mg/L), Pb (0.0148±0.009 mg/L), Zn (0.62± 0.16 mg/L), Cr (0.018±0.005 mg/L), Cu (0.11±0.05 mg/L), Fe (0.86±0.049 mg/L), Cd (0.014±0.004 mg/L), and Mn (0.031±0.004 mg/L). The concentrations for most of the parameters, tended to increase downstream along the river course; significant differences between the mean of studied area and that of the control (located upstream) were observed for most of the parameters - an indication of pollution load due to activities taken place in Sapele metropolis. The analysis however, reveals a low level of contaminations of the water resources; the water was slightly acidic. Turbidity, Cd and Fe ions contents were slightly higher than the Nigerian Standard for Drinking Water Quality (NSDWQ) and the World Health Organization (WHO) guidelines for drinking water standards, all others parameters, falls within the stipulated standards.*

KEYWORDS: *Water Quality, Physicochemical Characteristics, Sapele, Pollution, Metals*

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I. INTRODUCTION

Availability of water is fundamental for the sustenance of life and normal functioning of the ecosystems. Surface waters such as rivers, streams, lakes, and ponds provide a valued fresh water resource for mankind. Therefore, the contamination of this source, may represent a major threat to human health and ecosystem functions. Surface water – particularly river water – can be put to many uses which include: transportation of goods, generation of electric power, industrial uses such as production of goods and cooling of power plants, recreational and domestic uses. Surface water is also useful for irrigation of lands and serves as support for all forms of aquatic lives. The pollution of water bodies may hinder its capacity to support and sustain life; productivity, stability, species abundance, composition and diversity as well as physiological conditions of indigenous organisms may be largely affected. A river is indeed categorized as impaired, when it fails to performed at least one its functions, which include: fish protection and propagation, recreation, and public water supply, etc. [1]. Several factors have been implicated for the pollution of river water – both natural and anthropogenic. Natural sources may include; volcanic eruption, earthquakes, storms and algae blooms which can produce major changes in water quality and ecological status of the water. Topography and geological formations of the catchment also impact surface waters [2, 3].

However, most surface water pollution is almost entirely the results of human activities (i.e., anthropogenic). Wastes from domestic, municipal, artisans' workshops, mining, oil exploration and related activities, industrial, and agricultural activities are anthropogenic factors causing surface water pollution. Topography and geological formations create natural surface water run-off but the manipulation and perturbation of the land arising from constructions works and agricultural activities, increases flow rates and overall contamination. Poorly maintained waste systems enhanced by antagonistic weather incidents such as flooding can constitute a major source of surface water pollution. Pollution of rivers water as a result of anthropogenic activities has impacts on the inhabiting organisms, the plants irrigated by it, as well as animals and humans that drink and use it for domestic purposes or feeds on organisms (e.g., fishes, crabs) taken from the source. Thus, the need to examine the quality of river water to ascertain its fitness for various uses. In this work, the impact of urban activities on the physicochemical characteristics and metals' content of the Sapele section of the Benin-Ethiope river system was assessed with view ascertaining the potability and ability of the water to sustain aquatic lives.

II. MATERIALS AND METHODS.

2.1. Study area

Sapele (headquarter of sapele LGA) is situated on the bank of Benin river which is a continuum of the Ethiope river (the lower course of the Ethiope river in Sapele region to where it empties into the Atlantic is called the Benin river) with its source at Umutu, Delta State. Sapele is fairly industrialized town characterized by a number of manufacturing or processing businesses such as: the electricity power generating plant at Ogorode, food processing factories like Life Flour Mill Nigeria limited, and the various bakeries and eateries; bitumen producing company (Asca oil), Oil companies (e.g., Shell, Seplat), wood processing (various sawmills), rubber processing (Omatsteye Rubber Factory, Fortune George Spiropulous-FGS-Rubber Factory), etc. The town was also housing some others companies such as: Top Feed Nigeria ltd – a livestock feed processing plant and Eternit plc - a ceiling and roofing sheet industry – which were recently closed down. Besides, there are various artisans' such as welders, auto-mechanics, painters, carpenters, bricklayers etc. whose activities contributes to the bulk of wastes in the town. Effluent from some of these artisans and industrial units are release directly or indirectly into the river course. Other activities that may contributes to pollution of the river include the presence of Sapele Market and Abattoirs by the bank of the river. Domestic effluent from the town may also drains into the river system when it rains.

2.2. Sample collection

Samples were collected manually from the river at eight different strategic locations (AP, OK, AJ, PM, PT, MH, OJ, and OG) beginning upstream (AP) to OG (downstream) along the river course (Fig. 1). The sample taken at Amukpe (AP) where the river enters into Sapele was used as control. Precleaned Polyethylene bottles and Pyrex glass containers were used for samples collection. Pyrex glass containers were used for samples requiring determinations of organic constituents, while all others samples collections were done with Polyethylene bottles. Water samples were collected 3 – 10cm below the surface after thoroughly rinsing the containers with water about to be collected.

2.3. Sample preservation.

Soon after collection of samples, fast-changing parameters such as pH, temperature and conductivity were determined on site using portable meters. Samples for dissolved oxygen determination were fixed on the sites by adding manganous sulphate and sodium hydroxide-sodium iodide-sodium azide reagents. The precipitates formed and the supernatants were taken to the laboratory for subsequent analysis. The rest of the samples were placed in ice-chest and immediately taken to the laboratory. Analyses for anions were carried out within few hours after arrival at the laboratory but samples for sodium, potassium, calcium, manganese and trace of heavy metals were preserved by adding 5ml concentrated nitric acid to liter of sample [4, 5].

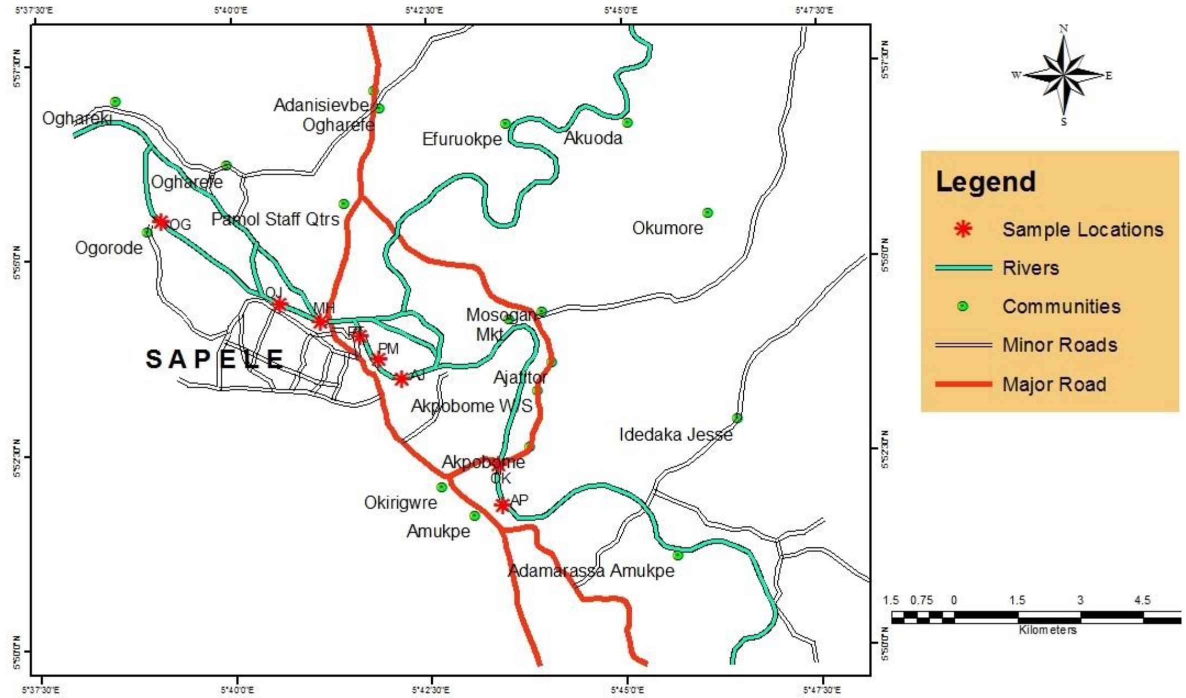

Fig. 1: Map of the study area showing the sampled locations.

2.4. Analyses of Samples

Analysis of samples were carried out using standard procedures [4, 5, 6]. The pH was determined with pH meter (model 410A) after standardization of the associated electrodes with buffer 9 and 4 respectively, temperature with a mercury bulb thermometer, turbidity by the turbidity meter after standardization with 0 and 10 NTU polymer standard solutions, conductivity (cond.) were determined with the aid of conductivity meter (model RE387TX), Total Suspended Solids (TSS) were obtained by filtering samples through a weighed standard glass fiber and drying to constant weight, Total Dissolved Solids (TDS) were measured using the same conductivity meter with TDS functional mode selected, the summation of TSS and TDS gives the Total Solids (TS). Dissolved Oxygen (DO) was measured by the azide modification of Winkler's method while the five-day Biochemical Oxygen Demand (BOD_5) were evaluated from depletion in oxygen content after a five-days incubation period. The Chemical Oxygen Demand (COD) were determined by oxidation with potassium dichromate followed by titration of the excess dichromate with ferrous ammonium sulfate. Chlorides were determined by the argentometric (Morh) titration method. Spectrophotometric determinations of nitrates (NO_3^-), nitrites (NO_2^-), and phosphates (PO_4^{3-}) were done using the phenoldisulphonic acid; sulphanilamide; and ascorbic acid methods respectively. Bicarbonates (HCO_3^-) were determined by the acidometric indicator-end-point method. Sulphates (SO_4^{2-}) were determined by turbidimetric method. The Oil and Grease (O&G) were extracted from aqueous portions into xylene. The absorbances of the extracts were then measured at 420nm on a spectrophotometer using xylene as reference. Total hardness and Ca^{2+} ions were determined by complexometric titrations with sodium salt of EDTA, and Mg^{2+} was estimated as difference in Total hardness and calcium. Na^+ and K^+ were determined by flame photometer. The other metals (Pb, Zn, Cu, Fe, Cd, & Mn) were determined with Atomic Adsorption Spectrophotometer (AAS) after necessary pre-concentrations and digestion with nitric acid.

2.5. Statistical analysis

Pearson's correlation coefficients and t-sampling statistics were used to find the relationships between variables, and to compare the variations in physicochemical properties of the studied area to that of the control site.

III. RESULTS

The values for some physicochemical parameters, concentrations of some anions and metals contents across the various sampling locations are shown in Tables 1 – 3. Table 4 gives the range and mean of the determined parameters in comparison with the control mean and the Nigerian Standard for Drinking Water Quality (NSDWQ) [7] and the World Health Organization (WHO) [8] guidelines for drinking water quality. Significant differences were observed between the mean of the control and the studied area for the following parameters: Cl^-, O&G, HCO_3^-, SO_4^{2-}, T. hardness, K, Cr, and Cd. The mean pH, Temp., DO, BOD, COD, NO_3^-, PO_4^{3-}, Ca, Mg, Na, Zn, and Cu, of the studied area showed very significant difference in comparison with the mean of the control. There were however, no significant difference in mean values of: conductivity, TDS, NO_2^-, Pb, and Mn, when compared to the control.

Table 1: values of some Physicochemical Parameters measured across sampling locations

	Parameters										
Samples	pH	Temp (°C)	DO mg/L	BOD mg/L	COD mg/L	TDS mg/L	TSS mg/L	Cond. µS/cm	Turb. (NTU)	O&G mg/L	T.Hardness ($mgCaCO_3/L$)
AP	6.58	25.20	7.80	1.08	4.00	8.60	16.00	17.20	6.7	0.86	0.675
OK	6.08	26.10	7.40	1.40	4.50	9.60	24.00	19.20	7.3	1.08	0.825
AJ	5.97	26.00	6.80	1.60	6.20	10.01	22.00	20.02	7.5	1.08	1.058
PM	5.76	26.20	6.20	1.29	5.80	19.60	20.00	39.20	7.0	1.14	0.792
PT	5.82	26.20	6.70	1.52	6.70	9.70	28.00	19.40	7.8	2.08	1.125
MH	5.84	26.10	6.50	1.80	6.30	9.82	30.00	19.64	8.4	2.30	1.333
OJ	5.96	26.60	5.90	2.20	5.20	10.80	36.00	21.60	9.3	2.01	1.383
OG	5.88	25.60	6.30	1.78	5.40	13.20	22.00	26.40	8.2	2.42	1.400

AP → Amukpe, OK → Okirigwre, AJ → Ajemele, PM → Peemos, PT → Port-two, MH → Market harbour, OJ → Oguanja, OG → Ogorode

Table 2: Concentrations of some anions across sampling locations

Samples	Parameters (mg/L)					
	Cl^-	NO_3^-	NO_2^-	PO_4^{3-}	HCO_3^-	SO_4^{2-}
AP	5.20	1.80	0.12	0.78	2.80	0.94
OK	6.13	2.48	0.18	1.01	3.00	1.05
AJ	5.37	3.00	0.01	1.20	2.50	1.14
PM	5.80	4.00	0.01	2.25	2.20	1.13
PT	6.00	5.10	0.25	2.30	4.10	1.97
MH	7.01	5.31	0.08	2.50	5.20	1.72
OJ	6.50	7.45	0.29	2.30	6.00	1.73
OG	9.18	6.60	0.21	1.63	5.90	1.73

AP → Amukpe, OK → Okirigwre, AJ → Ajemele, PM → Peemos, PT → Port-two, MH → Market harbour, OJ → Oguanja, OG → Ogorode

Table 3: Concentrations of some metals' ions across sampling locations

Samples	Parameters (mg/L)										
	Ca	Mg	Na	K	Pb	Zn	Cr	Cu	Fe	Cd	Mn
AP	0.12	0.09	0.51	0.23	0.007	0.15	0.012	0.028	0.80	0.008	0.030
OK	0.18	0.09	0.58	0.22	0.010	0.42	0.012	0.061	0.77	0.009	0.024
AJ	0.24	0.11	0.62	0.24	0.008	0.38	0.013	0.068	0.82	0.012	0.028
PM	0.10	0.13	0.64	0.25	0.0012	0.64	0.015	0.042	0.85	0.010	0.030
PT	0.25	0.12	0.67	0.32	0.030	0.72	0.025	0.108	0.88	0.015	0.031
MH	0.30	0.14	0.66	0.30	0.018	0.65	0.020	0.170	0.86	0.017	0.033
OJ	0.32	0.14	0.67	0.38	0.016	0.74	0.021	0.128	0.92	0.017	0.035
OG	0.31	0.15	0.72	0.42	0.021	0.82	0.023	0.169	0.89	0.018	0.036

AP → Amukpe, OK → Okirigwre, AJ → Ajemele, PM → Peemos, PT → Port-two, MH → Market harbour, OJ → Oguanja, OG → Ogorode

Table 4: Range and mean of the determined parameters in comparison with the control and standards (n = 3 for control, n = 21 for the study area)

Parameters	Range	Control Mean ± SD	Study area Mean ± SD	Standard
pH	5.76 – 6.58	6.58 ± 0.01	5.90 ± 0.11[vs]	6.5 – 8.5[a]
Temp (°C)	25.20 – 26.60	25.20 ± 0.03	26.11 ± 0.30[vs]	Ambient[a]
DO (mg/L)	5.90 – 7.80	7.80 ± 0.06	6.54 ± 0.49[vs]	
BOD (mg/L)	1.08 – 2.20	1.08 ± 0.04	1.66 ± 0.30[vs]	
COD (mg/L)	4.00 – 6.70	4.00 ± 0.10	5.73 ± 0.75[vs]	
TDS (mg/L)	8.60 – 19.60	8.60 ± 0.46	11.82 ± 3.7[ns]	500[a]
TSS (mg/L)	16.00 – 36.00	16.00 ± 0.71	26.00 ± 5.66[vs]	
Cond. (µS/cm)	17.20 – 39.20	17.20 ± 0.90	23.64 ± 7.31[ns]	1000[a]
Turb. (NTU)	6.7 – 9.3	6.7 ± 0.10	7.93± 0.77[vs]	5[a]
O&G (mg/L)	0.86 – 2.42	0.86 ± 0.075	1.73 ± 0.60[s]	
Cl^- (mg/L)	5.20 – 9.18	5.20 ± 0.16	6.57 ± 1.26[s]	250[a]
NO_3^- (mg/L)	1.00 -7.45	1.80 ± 0.23	4.85 ± 1.82[vs]	50[ab]
NO_2^- (mg/L)	0.01 – 0.29	0.12 ± 0.01	0.15 ± 0.11[ns]	0.2[a] (3[b])
PO_4^{3-} (mg/L)	0.78 – 2.50	0.78 ± 0.07	1.88 ± 0.60[vs]	
HCO_3^- (mg/L)	2.20 – 6.00	2.80 ± 0.20	4.13 ± 1.60[s]	
SO_4^{2-} (mg/L)	0.94 – 1.97	0.94 ± 0.05	1.50 ± 0.38s	100
Ca (mg/L)	0.10 – 0.32	0.12 ± 0.01	0.243 ± 0.08[vs]	
Mg (mg/L)	0.09 – 0.15	0.090 ± 0.002	0.126 ± 0.02[vs]	
T. Hardness ($mgCaCO_3/L$)	0.675 – 1.400	0.675 ± 0.03	1.074 ± 0.29[s]	150[a]
Na (mg/L)	0.51 – 0.72	0.51 ± 0.01	0.65 ± 0.04[vs]	200[a]

K (mg/L)	0.22 – 0.42	0.23 ± 0.01	0.30 ± 0.07s	
Pb (mg/L)	0.007 – 0.030	0.007 ± 0.001	0.0148 ± 0.009[ns]	0.01[ab]
Zn (mg/L)	0.15 – 0.82	0.15 ± 0.021	0.62 ± 0.16[vs]	3a
Cr (mg/L)	0.012 – 0.025	0.012 ± 0.001	0.018 ± 0.005[s]	0.05[ab]
Cu (mg/L)	0.028 – 0.170	0.028 ± 0.006	0.11 ± 0.05[vs]	1[a] (2[b])
Fe (mg/L)	0.77 – 0.92	0.80 ± 0.006	0.86 ± 0.049[s]	0.3[a]
Cd (mg/L)	0.008 – 0.018	0.008 ± 0.001	0.014 ± 0.004[s]	0.003[ab]
Mn (mg/L)	0.024 – 0.036	0.030 ± 0.001	0.031 ± 0.004[ns]	0.2[a] (0.4[b])

[a] Nigerian Standard for Drinking Water Quality (NSDWQ) [7], [b] World Health Organization (WHO) [8] guidelines for drinking water quality. The letters ns, s, and vs respectively denote that the study area mean is not significant, significant, and very significantly different from that of the control mean.

IV. DISCUSSION

The averaged pH for the river water was 5.90± 0.11 with a range of 5.76 – 6.58. This shows that the water is slightly acidic; with pH of all the samples except that of the control (AP) been below the recommended minimum allowable value of 6.5 for drinking water set by the Nigerian Standard for Drinking Water Quality (NSDWQ) [7], and the World Health Organization (WHO) [8] guidelines for drinking water quality, it is however suitable for sustenance of aquatic life. The temperatures were slightly constant with an average of 26.11 ± 0.30^{o}C. The range of temperatures (25.20 – 26.60^{o}C) obtained in this research were in the normal range for sustenance of aquatic life. Elevated temperature in water bodies, increases microbial activities with consequent fall in oxygen content that could cause fish kill and alter food chain composition. The Dissolved Oxygen (DO) for the river waters tended to decrease along the river course as one moves from Amukpe (AP) through Sapele metropolis. This could be as a result of increasing pollution load. The control (AP) has value of 7.80mg/L. This decreases along the source to a value of 5.90mg/L at Oguanja (OJ). The average DO for all the sampling stations excluding the control sample was 6.54 ± 0.49mg/L. This figure however satisfies the minimum requirement for aquatic life to prevent oxygen deficiency.

The biochemical oxygen demand (BOD) tended to increase along the river course from Amukpe through sapele metropolis. The BOD for the (control) point was 1.08mg/L. This increases up to 2.2mg/L at Oguanja (OJ) and then decrease slightly to 1.78mg/L at Ogorode. Similar increase in Chemical Oxygen Demand (COD) from 4.00mg/L at the control to 6.70mg/L at Market Harbour (MH) and then a slight decrease to 5.40mg/L at Ogorode was observed. The increase in BODs and CODs could be adduced to increase in concentrations of organic pollutants along the River course. The organic loads appear to be at a maximum at the MH and OJ. The BODs and CODs values decrease a little afterward. The average value of BODs for the river water was 1.66 ± 0.30mg/L, while that of CODs was 5.73 ± 0.75mg/L. There was a corresponding increase in both BODs and CODs values for most samples along the river course. This is expected as both measure the quantity of pollutants subject to bacteria or oxidizers' action. The values however reflected low level of organic pollution, tolerable and capable of been clean-up by the natural purification schemes.

The Total Dissolved Solids (TDS) for the waters ranged from 8.60mg/L at the control to 13.20mg/L at Ogorode. However, there was no regular pattern of increase as the values tended to fluctuate along the river course. This might be due to slight changes in temperatures, pH and other factors, which might cause precipitations of particles out of solution or the dissolutions of suspended solute. The highest value of TDS (19.60mg/L) was recorded around Peemos. The range and the average value (11.82 ± 3.7mg/L) obtained in this report is reflective of a typical freshwater environment. The Total Suspended Solids (TSS) at the control (AP) was16.00mg/L, 24.00mg/L at Okirigwre, 22.00mg/L and 20.00mg/L at Ajemele and Peemos respectively and then increased to 28.00, 30.00 and 36.00mg/L at Port-two, Market harbour and Oguanja respectively. The relatively high value at Oguanja is likely due to contamination of the water by sawdust arising from sawmills activities taking place in this area. The TSS at Ogorode was 22.00mg/L. The conductivity values took the same trend as TDS as both has direct relationship.

The mean of turbidity for river waters was 7.9 ± 0.77NTU. The control (AP) value was 6.70NTU. This increases along the river course as one moves from Amukpe through Sapele metropolis to a maximum of 9.3NTU at Oguanja. The value at Ogorode was 8.2NTU. This decrease may be ascribed to dilution effect. These values are however, in the neighbourhood of desirable level of 5units and the maximum allowable level of 25units for drinking water quality. Turbidity may arise from the presence of fine-dispersed suspended particles such as clay, silica, grain, organic matter etc., it may indicate the presence large number of micro-organisms. High turbidity does not always imply the that the water is unfit for drinking purpose, it may however make the water aesthetically unsuitable.

The values recorded for Oil and Grease (O&G) was also increased from the control at Amukpe through Sapele metropolis. A value of 0.86mg/L was observed at the control (AP). This increased gradually to 2.42mg/L at Ogorode port. The relatively high value of 2.08 and 2.30mg/L recorded at Port-two and Market harbour respectively might be ascribed to the activities such as car wash at the Port-two site and run-off to the river from the Market place which also housed an abattoir. Pollution from speed boat engines and drains from Ogorode power station and effluent from adjacent ASCA oil company might have contributed to the high oil and grease content at Ogorode port.

The chloride value at Amukpe (control) was 5.20mg/L. The values for some other locations were: PM (6.00mg/L), PT (7.01mg/L), OJ (6.50mg/L), and OG (9.18mg/L). These values however do not exceed the standard by the Nigerian Standard for Drinking water Quality (NSDWQ) [7] and the World Health Organization (WHO) [8] guidelines for drinking water quality. The nitrates level of the river water at Amukpe was 1.80mg/L. This increase to a maximum at Oguanja with value of 7.45mg/L. The activities at Oguanja outside sawmilling, such as open defecations and dumping of refuse as well as run off from adjacent farms have probably increase the nitrates concentrations in location. The values for nitrites (NO_2^-) range from 0.01 – 0.24mg/L with a mean of 0.15 ± 0.11mg/L. There was some degree of correlations between NO_3^- and NO_2^-, though not significant at 5% probability. Nitrate concentrations above maximum allowable level in human body causes methemoglobinemia, increase infant mortality, abortions, birth defects, cancer, histopathological changes, hypertension and deterioration of the immune system [9]. Nitrates have also been implicated as a major cause of eutrophication of water bodies [8, 11, 12, 13]. The mean value for phosphates was 1.88 ± 0.60mg/L drawn from a range of 0.78 – 2.50mg/L. The value for the control (AP) was 0.78mg/L. The values for the others locations were: OK (1.01mg/L), AJ (1.20mg/L), PM (2.25mg/L), PT (2.30mg/L), MH (2.50mg/L), OJ (2.30mg/L), and OG (1.63mg/L). The comparatively high values found for Port-two, Market harbour, and Oguanja, relative to the control could be attributed largely to laundry activities in which polyphosphates detergents are used. The increase in the amount of nutrients (PO_4^{3-} and NO_3^-) accounted for the increase growth of plants along the course of the river. High values of sulphates were similarly observed at some of the above points; values of 1.97, 1.72, and 1.73mg/L as against 0.94mg/L of the control were recorded. This again could be attributed from the use of linear alkyl benzene sulphonates (LAS) and alkyl benzene sulphonates (ABS) detergents and run off from drains. Geol and Kaur [14] have shown that the use of household detergent in laundry, contribute to increased level of sulphate contamination in water body. Wang and Zhang [15] have also identified synthetic detergents as major source of sulphate contamination in water environment. The highest value of bicarbonates for the river water was 5.90mg/L, which was observed at Ogorode as against the control point of 2.80mg/L.

The calcium and magnesium content for most samples increase along the river course. The maximum value of 0.32 and 0.14mg/L respectively as against 0.12 and 0.09mg/L of the control. The range of values however, shows the low-level hardness of the river. The concentration of sodium in the river water average 0.65 ± 0.04mg/L. There was a gradual increase downstream from Amukpe through Sapele metropolis. The tidal inflow of salty water from the sea might have contributed to the high value of 0.72mg/L at Ogorode as against 0.51mg/L at the control. The potassium content for the river waters also increased from 0.23mg/L at the control (Amukpe) to 0.42mg/L at Ogorode. The concentration of lead in the river waters ranges from 0.007 - 0.030mg/L. The values increased gradually downstream from Amukpe through Sapele until it got to Port-two (PT) where there was mark increase. The maximum value (0.030mg/L) which was recorded at this site could have resulted from this river being used constantly for car wash and other activities. This value for lead finally decreases to 0.021mg/L at Ogorode due to dilution effect. The values were however, below the maximum permissible standard of 0.10mg/L by [7] and [8]. Lead is a systemic toxicant, that exacts a wide-ranging effect on the human body [16]. The average zinc content was 0.62 ± 0.16mg/L. The concentrations were found to increase slightly from Amukpe through Sapele metropolis. This is most probably due to increase human activities as one moves downstream. The highest value (0.74mg/L) recorded however, still falls within the 3mg/L desirable level for Zn set by [7] and [8]. Zinc though an essential element, when presence in excess amount in the human body can results in system dysfunctions with consequent impairment in growth and development [17, 18]. The chromium content of the river averaged 0.018±0.005mg/L, taken from a range of 0.012 - 0.025mg/L for the different sampling stations. Port-two which is exposed to regular washing of motor cars, recorded the highest concentrations of 0.025mg/L. The values of 0.020, 0.021, and 0.023mg/L were recorded at the market harbour, Oguanja, and Ogorode respectively.

The copper content of the River waters increased from 0.028mg/L at the control through Sapele metropolis to 0.169mg/L at Ogorode. The highest value (0.170mg/L) was recorded at the market harbour. The average value of copper concentration of the river water was 0.0096 ± 0.0052mg/L. This value was well within the maximum desirable level of 1mg/L recommended by [7]. The iron concentration of the water increased gradually downstream from Amukpe through Sapele metropolis due to increasing pollution load. The highest value of 0.92mg/L was recorded at Oguanja as against 0.80mg/L at the control point. A lot of activities such as car wash at Port-two; blacksmithing at Oguanja area; drains from rusted roofs at the market place etc. could have contributed to this increase in concentrations downstream. These values are above the desirable level of 0.3mg/L stipulated by [7]. Iron stains laundry and plumbing fixtures may occur at concentrations above 0.3mg/L, turbidity and colour may also develop [8]. The average concentration of cadmium was 0.014 ±0.004mg/L; this is much higher than the highest desirable level of 0.003mg/L. The values were noted to increase from 0.008mg/L at AP to 0.018mg/L at OG. Cadmium is a known cause of cancer of the prostrates and testis, it modulates gene expression and signal transduction [19, 20]. The manganese concentration at AP (control) for the river was 0.003mg/L. it decreases to 0.024mg/L at Okirigwre and then increase downstream through the metropolis to a maximum (0.036mg/L) at Ogorode (OG). The average value was 0.031 ± 0.004mg/l. The values are however, within the limits of 0.2 and 0.4mg/L established by [7] and [8] respectively.

Daka et al [21], obtained concentrations (mg/L) range of Cr, Cu and Fe (with mean in parenthesis): Cr 0.024 – 0.057 (0.043±0.011), Cu <0.001 – 0.265 (0.175±0.106), and Fe 0.244 – 0.759 (0.395±0.196) for surface water in some oil field communities in the Niger Delta, Nigeria. The mean obtained in this report tended to be lower (except for Fe) than that reported by Daka et al [21]. Their studies also, showed higher variations in concentrations of sampled sites. The range of values of heavy metals concentrations obtained in this study were however higher than the 0.004 – 0.015mg/L Cd, 0.004 – 0.015mg/L Pb, 0.050 – 0.060mg/L Zn and 0.01 – 0.04mg/L Cu obtained by Amoo et al [22] for most water samples of Lake Kainji, Nigeria. The mean concentrations obtained for most heavy metals in this study were lower than the mean values recorded by Olantunji and Osibanjo [23] for inland fresh water of lower River Niger drainage in North Central Nigeria viz: Pb (0.03±0.02mg/L), Zn (2.27±0.57mg/L), Cr (2.08±1.27mg/L), Cu (2.17±0.73mg/L), and Cd (0.05±0.73mg/L). They were also lower than the mean of 2.05±0.32mg/L Zn, 2.85±0.53mg/L Cu, 0.38±0.02mg/L Pb, 0.66±0.46mg/L Cr, and 0.04±0.00mg/L Cd reported by Dabai et al [24] for surface water in some oil field communities in Niger Delta, Nigeria. The most abundant heavy metal in the surface water was iron (Fe) while the least was cadmium (Cd). The order of their relative abundance was: Fe > Zn > Cu > Mn > Cr > Pb > Cd.

V. CONCLUSION

The study was undertaken to determine the impacts of urban activities on the physicochemical characteristics and metals' content of Sapele section of the Benin-Ethiope river system. The results showed that there were increase in concentrations of most anions and metals ions as well as the BODs and CODs of the river water as one moves downstream from Amukpe through Sapele metropolis. This is an indication of pollution due to activities taking place in Sapele metropolis. For most of the parameters, the values obtained were within the Nigerian Standard for Drinking Water Quality (NSDWQ) and World Health Organizations (WHO) guidelines for drinking water standards. The acidic nature and the concentrations of cadmium in the river however were slightly higher than the recommended standard for drinking water. The water thus, requires treatment before its use as potable water. The present status of the river water meets the requirement for aquatic lives. However, because of possible bioaccumulations of heavy metals in fishes and human, effort should be put in place to discourage further depletions of the water by ensuring industries in the town comply with limitation standards set by the appropriate agency in the discharge of their effluents. Also, the Department of Environment in Sapele in conjunction with the State and Federal Ministries should carry out public enlightenment to discourage the dumping of wastes in water bodies; modern treatment plants and waste disposal systems should be provided to prevent dumping of waste into surface waters.

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