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Effects of anthropogenic activities on water quality, and phosphate and nitrates in the sediment of River Ogun at Ijaye, Isabo and Oke-sokori, Ogun State

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ABSTRACT

Water pollution is an issue of concern over the years in many countries. This study investigated the effect of human activities on the water and soil sediments of River Ogun at Ijaye, Isabo and Sokori from June to November 2017. The physico-chemical parameters of the water in all the three locations were measured and recorded twice monthly using standard methods. Determination of phosphate and nitrate in the soil was carried out. One-way analysis of variance was employed for data analyses, and means were differentiated using Duncan multiple range tests. No significant difference (p>0.05) in the mean of all the parameters tested for in all three locations. Monthly range in temperature was within 24.75 ºC- 27.55 ºC. Highest mean electrical conductivity (531.00 µs/cm), dissolved oxygen (7.56 mg/l) and alkalinity (2.80 mg/l) were recorded at Location C (Oke-Sokori). High positive correlation was obtained between water phosphate and water nitrate, soil phosphate, soil nitrate and between pH and dissolve oxygen, electrical conductivity. It was concluded that the water from all three locations are still within the recommended reference for fish. There is need to constantly monitor the water at these locations as levels of some of the parameters have exceeded the permissible limit for fish.

Keywords: Dissolve oxygen, Electrical conductivity, River Ogun, sediment, water quality parameter.

INTRODUCTION

Rivers and lakes are a part of human history and have been largely utilized by mankind with time, such that they have been greatly affected by human activities leaving few or non in its 'natural' state. Rivers around urban areas are characterized with pollution and water quality problems due basically to careless disposal of waste from industrial effluents and other point and non point source into rivers (Chindah et al., 2004; Emongore et al., 2005). Ever increasing world population, soil erosion, intensive deforestation, urbanization, hydrological change, and inadequate water use have caused major reduction in the river water quality. This situation in the urban areas continues to increase due to careless disposal of industrial waste and defective drainage system.

Human activities has greatly impacted on suspended sediment loads in major rivers of the world and have been largely studied including in Africa and Nigeria (Isik et al., 2008; Ayobahan et al., 2014; Abdulraheem et

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al., 2017; Owuor et al., 2018). Abdulraheem et al., (2017) reported that there are heavy concentrations of Zn, Pb, and Cu beyond the acceptable limits in River Sokori which could be harmful to the fisheries resources of this water body, and the populace who rely on this water body through the food chain.

There had been significant increase in population growth and industrial activities around this water body in the recent years, and little or no information had been documented regarding the pollution state of this water body at these points. This study was therefore designed with the focus on the quality of the water and soil sediments of the River Ogun at Ijaye, Isabo and Sokori.

MATERIALS AND METHODS

Study area

The study was carried out in urban areas of Abeokuta, the capital of Ogun State, Nigeria. Abeokuta is in the sub-humid tropical region of Southwestern Nigeria, and lies between latitude 7°5′N-7°20′N and longitude 3°17′E-3°27′E. It has a population of 605,451 (Projected from 1991 Census of 374,043 at 3.5 % growth rate). Its geographical location makes it easily accessible from Lagos, the industrial capital of Nigeria and the nation's major seaport. The city covers a geographical area of 1,256 km^2, which include Abeokuta South, Abeokuta North and part of Obafemi Owode and Odeda Local Government Areas of Ogun State. The major activities in Abeokuta are trading, textile making, artisans and transportation activities. Houses in these areas are densely populated with about six to twenty persons per house.

Water sample collection

Water samples for physico-chemical analysis were collected from all the locations bi-monthly from June – November 2017. The samples were then taken to a quality control laboratory immediately for physical and chemical analysis of the following parameters: Dissolved oxygen, Electrical Conductivity, pH, Acidity, Alkalinity.

Dissolved oxygen analysis

Dissolved oxygen was analyzed for using the Winkler's method as described by Olalekan et al. (2012). Chemicals used include Manganese II sulphide ($MnSO_4$) solution, alkali-iodide-azide, concentrated sulphuric acid (H_2SO_4), Sodium thiosulphate ($Na_2S_2O_3.5H_2O$) solution with starch solution as reagent. To the DO bottle containing the sample, 2 ml of $MnSO_4$ solution was added and another 2 ml of alkali-iodide-azide solution was also added and the sample bottle was corked and thoroughly mixed. A hundred millilitre of the mixture was measured into a conical flask using a measuring cylinder and six drops of the indicator (starch solution) was added. It was then titrated with the standard $Na_2S_2O_3.5H_2O$ in the burette until the colour change to colourless From the average titer values obtained for each station, the dissolved oxygen concentration was calculated in mg/l using the formula

O_2 mg/l = t x 101.6 20 ml of water sample

Where t = titer or volume of thiosulphate used.

101.6 = constant.

Measurement of alkalinity

Concentrated Hydrochloric acid (HCl) was used as reagent, phenolphthalein and methyl orange as indicator. A Hundred millilitre of the sample was poured into a conical flask, 2 drops of phenolphthalein indicator was added and no colour change was observed. Two drops of methyl orange indicator was then added, and titrated against 0.2 M concentrated HCl till a pink end point was observed.

Phosphate in the water body

One hundred millilitre of water sample was measured into a conical flask. 5 ml of conditioning reagent was added to the sample. Reading was taken using 6405 UV\Vis Spectrometer at 220 nm wavelengths (Mcneely et al., 1979).

Nitrate in the water body

One millilitre of HCl was put into a nitrate bottle using a pipette. Twenty-five millilitre of water sample was put inside a standard flask. Four millilitre of distilled water was added and reading was done using 6405 UV\Vis Spectrometer at a wavelength of 220 nautical miles (Mcneely et al., 1979).

Soil sediment collection

The sediment was collected at the bank of the river in all locations by hand into a sterilized container. This was then air dried for some days and taken to the laboratory for analysis.

Nitrate analysis in sediment sample

The collected sediment samples were sieved using a 0.5 mm mesh sieve. Ten grams of the sieved sediment was then measured using a weighing balance and put into a sampling bottle of 130 ml. Twenty millilitre of potassium sulphate (K_2SO_4) was also added into the sampling bottle. The mixture was kept in an orbital shaker for about 30 minutes. Mixture was filtered, and the filtrate kept in a sampling bottle. One millilitre of salicyclic acid and 10 ml of sodium hydroxide (NaOH) were added to the filtrate which was observed for an hour for colour change (chlorination). The readings were done using 6405 UV\Vis Spectrometer with a wavelength of 220 nm.

Phosphate analysis in sediment sample.

Five grams of sieved sediment was measured into a sampling bottle and 25 ml of Bray solution was added. The mixture was filtered into a sampling bottle using Whattman filter paper 110 mm diameters. 8 ml of filtrate was measured into another sampling bottle and 25 ml of Bray solution was added to another disposable scintillating vials. 10 drops of phosphorus reagent B was added and observed for 1 hour. Afterward, 10 drops of phosphorus reagent C was also added. The reading was done using 6405 UV\Vis Nanometer with a wavelength of 220 nm.

Data analysis

The data collected were subjected to one-way ANOVA analysis using the general linear model of the Statistical Package Social Sciences 16.0 (SPSS 16), and the mean differentiated using Duncan's multiple range tests.

RESULTS

Physico-chemical parameters

The result of the physico-chemical parameters was presented in Tables 1, 2 and 3. The highest mean water temperature (27.75 ºC) and the lowest mean water temperature (24.75 ^oC) were recorded at location A (Ijaye). The highest mean pH (7.23) was obtained in location A (Ijaye). The lowest mean water phosphate (6.55 mg/l), water nitrate (9.14 mg/l), soil phosphate (7.16 mg/kg) and soil nitrate (9.91 mg/kg) were recorded at Location A (Ijaye). The highest mean electrical conductivity (531.00 µs/cm), dissolved oxygen (7.56 mg/l) and alkalinity (2.80 mg/l) were recorded at Location C (Oke-Sokori). There was no significant difference ($p > 0.05$) in the mean of all the parameters tested for in all the three locations. All parameters were compared with various national and international standards (Table 4).

Correlation between the water quality parameters and sediment

Table 5 represents the correlation analysis between the water quality parameter and sediment. The correlation result showed a significant ($P<0.05$) correlation at the 95% confidence limit. Strong positive correlation was recorded between the level of phosphate in the soil and in the water as calculated 'r' was 0.967 mg/l. Soil nitrate levels gave a strong positive relationship with that in the water with calculated 'r' 0.997 mg/l. Soil nitrate also had a strong positive relationship with water nitrate and *viz a viz*. There was strong positive relationship between water pH and electrical conductivity and DO. Negative correlation was recorded between pH in water and nitrate and phosphate.

Table 1: Mean monthly variation of physico-chemical parameters at location A (Ijaye).

Months	**Parameters**									
	Air temp (°C)	**Water temp (°C)**	**pH**	**EC (µs/cm)**	**Alkalinity (mg/l)**	**DO (mg/l)**	**Water phosphate (mg/l)**	**Water nitrate (mg/l)**	**Soil phosphate (mg/kg)**	**Soil nitrate (mg/kg)**
June	28.60	27.75	6.58	495.00	1.75	4.60	6.67	9.19	7.25	9.95
July	28.20	26.75	6.54	505.00	1.75	4.51	6.85	9.15	7.28	9.91
August	28.00	26.10	6.71	505.00	1.58	5.18	6.55	9.14	7.33	10.15
September	29.70	25.25	6.72	496.00	1.60	6.15	6.71	9.17	7.30	10.00
October	27.50	24.75	7.05	525.00	1.57	6.85	6.87	9.36	7.16	9.93
November	27.75	26.15	7.23	495.00	1.55	7.20	7.20	9.37	7.27	9.91

Key: Air temp- Air temperature, Water temp- water temperature, EC- Electrical conductivity, DO- Dissolve oxygen.

Table 2: Mean monthly variation of physico-chemical parameters at location B (Isabo).

Monthly	**Parameters**									
	Air temp (°C)	**Water temp (°C)**	**pH**	**EC (µs/cm)**	**Alkalinity (mg/l)**	**DO (mg/l)**	**Phosphate in water (mg/l)**	**Nitrate in water (mg/l)**	**Soil phosphate (mg/kg)**	**Soil nitrate (mg/kg)**
June	28.50	27.40	5.44	440.00	1.53	4.18	8.67	16.56	8.95	16.93
July	28.20	26.70	5.44	450.00	1.54	4.45	8.64	16.56	9.01	16.94
August	28.50	26.50	5.80	443.50	1.54	2.95	8.53	16.62	9.01	16.95
September	29.40	25.20	5.81	457.50	1.57	5.20	8.63	16.59	8.95	16.89
October	27.85	25.50	5.93	500.00	1.54	5.31	8.65	16.60	8.94	17.01
November	28.25	26.00	6.00	495.00	1.48	5.55	8.74	16.62	8.97	16.99

Key: Air temp- Air temperature, Water temp- water temperature, EC- Electrical conductivity, DO- Dissolve oxygen.

Table 3: Mean monthly variation of physico-chemical parameters at location C (Oke-Sokori) Mean monthly variation of physico-chemical parameters at location C (Oke-Sokori).

Month	Parameters									
	Air temp (°C)	**Water temp (°C)**	**pH**	**EC**	**Alkalinity (mg/l)**	**DO (mg/l)**	**Water phosphate (mg/l)**	**Water Nitrate (mg/l)**	**Soil phosphate (mg/kg)**	**Soil nitrate (mg/kg)**
June	28.30	27.50	6.44	450.00	1.95	4.60	8.21	14.54	8.80	14.55
July	28.50	27.50	6.32	485.00	1.97	5.05	8.34	14.54	9.12	14.67
August	28.70	26.85	6.71	502.50	1.95	5.83	8.39	14.54	8.95	14.81
September	28.45	25.50	6.98	511.00	2.20	7.56	8.49	14.58	8.94	14.65
October	28.75	27.00	7.02	531.00	2.46	7.16	8.44	14.45	9.00	14.79
November	29.00	27.25	7.03	517.50	2.80	6.74	8.46	14.54	9.08	14.78

Key: Air temp- Air temperature, Water temp- water temperature, EC- Electrical conductivity, DO- Dissolve oxygen

Table 4*:* Selected national and international water quality standard.

Parameter	Maximum permissible limits in water						
	NAFDAC	**SON**	**FEPA**	**NSDW**	**WHO**	**EU**	**USEPA**
Conductivity (μs/cm)	1000	1000	70	1000			
Total dissolved solids (mg/l)	500	500	500	500	1000		500
pH	6.5–8.5	6.5–8.5	6.0–9.0	6.5–8.5	6.8	6.5–9.5	6.5–8.5
Total hardness	100	100		150	100		
Total alkalinity (mg/l)	100	100			100		
Nitrate (mg/l)	10	10	20	50	50	50	10
Water temperature (°C)			26		40		
Dissolved oxygen (mg/l)			$\geq$ 4		$\geq$ 6		

Key: AFDAC-National Administration for Food, Drugs and Control, SON-Standard Organization of Nigeria, FEPA-Federal Environmental Protection Agency, NSDW-Nigerian Standard for Drinking water, USEPA-United States Environmental Protection Agency, EU-European Union and WHO-World Health Organization. **Source:** Oketola et al. (2006).

Table 5: Linear correlation coefficient of the parameters.

	Air Temp (°C)	Water Temp (°C)	pH	EC (µs/cm)	Alkalinity	DO (mg/l)	Phosphate (mg/l)	Nitrate(mg/l)	Soil Phosphate (mg/kg)	Soil Nitrate (mg/kg)
Air Temp (°C)	1									
Water Temp (°C)	0.164	1								
pH	-0.032	-0.083	1							
EC (µs/cm)	-0.018	-/0.173	0.781*	1						
Alkalinity	0.252	0.383	0.516	0.459	1					
DO (mg/l)	0.066	-0.333	0.728*	0.686	0.458	1				
Phosphate (mg/l)	0.087	0.147	-0.502	-0.349	0.233	-0.107	1			
Nitrate(mg/l)	0.101	0.125	-0.647	-0.464	0.094	-0.264	0.975*	1		
Soil Phosphate	0.118	0.230	-0.454	-0.314	0.337	-0.145	0.967*	0.948*	1	
Soil Nitrate	0.112	0.121	-0.675	-0.470	0.063	-0.283	0.963*	0.997*	0.933*	1

***correlation is significant at l.

DISCUSSION

Increase observed in phosphate and nitrate levels both in water and sediment during the sampling period could be due to discharge and sedimentation of suspended particulates from phosphate and nitrogen fertilizers and from domestic waste into the river which was aided by rainfall in these months, thereby increasing the phosphate and nitrate content in the sediment. This is due to anthropogenic activities, associated mainly with urban migration and industrialization, which have resulted to increasing pollution of water bodies (Ayoola and Ajani, 2009).

Normal levels of these minerals though pose no threat to fish survival and performance; high levels can create conditions that can make fish survival impossible. According to Davidson et al. (2014), high levels of nitrates in fish aquaria resulted to prevalence of side swimming, slightly slower growth, decreased survival, and chronic health problems in juvenile rainbow trout. Also, high positive correlation was obtained for pH level and the levels of electrical conductivity, and dissolved oxygen at these locations.

There are documented evidences that any increase or decrease in pH outside the recommended limit for fish culture can result to death of the fisheries resources. According to Ikuta et al. (2003) low pH significantly inhibited the reproductive behavior of mature hime salmon *Oncorhynchus nerka*, brown trout *Salmo trutta* and Japanese char *Salvelinus leucomaenis*. Also, Reynalte-Tataje et al. (2015) reported an almost total mortality of incubated eggs of curimbatá *Prochilodus lineatus* at pH 5. Scott et al. (2005) reported a pronounced disruption of ammonia excretion in perch (*Perca fluviatilis*) exposed to pH 9.90.

Dissolve oxygen, an important parameter for survival of animal life including fish revealed a high positive correlation with the water pH, indicating that any increase in water pH will mean a corresponding effect in the DO levels of the water. Bagherzadeh Lakani et al. (2013) reported a significant effect on growth rate of *Huso huso* due to reduction in feed intake and a corresponding changes in stress response accompanied low dissolved oxygen. Low dissolved oxygen value (2.9 mg/l) recorded in location B (Isabo) for the month of August compared with other months and locations could be attributed to high level of organic decompositions resulting from domestic discharge and industrial effluent. Low and over saturated DO levels was reported to affect growth and food conversion ratio in fish negatively (Mallya, 2007).

Electrical conductivity at these study locations during the study was higher than the permissible limit for fish survival (Oketola et al., 2006). The maximum value was found to be in the month of October which could be due to reduced water volume and the rich nutrient content of the water and corroborated the findings of Ibrahim, Auta and Balogun (2009). The values were within the acceptable limits of (Environmental Protection Agency, 2001; Standard Organization of Nigeria, 2007) standards. Variations in conductivity on a monthly basis at the different locations could be due to types of human activities in the catchment, and to the extent of usage of the water for irrigation.

Conclusion

It can be concluded that the water from all three locations are still within the recommended reference for fish. Also with exclusion of pH, temperature and DO, other parameters have already exceeded the reference range for fish growth and survival. There is need for constant monitoring of these locations to protect the fisheries resources.

COMPETING INTERESTS

The author declares that there were no competing interests.

AUTHORS' CONTRIBUTIONS

AFI designed the study and sample collection and data analysis were by him. He analyzed study results, statistics and interpretation and wrote the draft and final manuscript.

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