

# A COMPARATIVE LIMNOLOGICAL AND WATER QUALITY ASSESSMENT OF SOME RIVERS IN BENIN CITY AND PERI-URBAN AREAS, EDO STATE, NIGERIA.

BY

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**A comparative water quality assessment of five rivers located in Benin City and peri-urban areas was undertaken between December 2001 and July 2002. The physico-chemical parameters investigated were pH, turbidity, conductivity, total dissolved solids (TDS), dissolved oxygen (DO), nitrate and sulphate. Turbidity, pH, nitrate and sulphate values were significantly different in the rivers (P<0.05). Electrical Conductivity and TDS were positively correlated showing their over-riding importance in determining trophic status and nutrient content of the rivers studied. The rivers were remarkably low in nutrients and there was no discernible seasonal pattern in the variability of the parameters studied. Although most of the parameters measured did not exceed the WHO/FEPA standards for drinking water, it is recommended that water from these rivers must be treated to avoid possible health hazard.**

**Keywords:** Physical, chemical, water quality, rivers, nutrients.

## INTRODUCTION

Surface waters from streams, rivers and river basins have supported human habitations from time immemorial. Water is an important compound that covers approximately 75% of the earth's surface, existing in all the three states of matter as ice, liquid and steam. Rivers usually flow from upland sources to a large lake or to the sea, fed by such sources as springs and tributary streams. Water is used in many ways from drinking to industrial and agricultural processes (Tisser *et al.*, 2008b, Akpan, *et al.*, 2009).

Humans can have profound influence on the chemistry of a water body. Excessive landscape disturbance causes higher rates of leaching and erosion by removing vegetative cover, exposing soil and increasing water runoff velocity. Lawn fertilizers, waste water and urban storm water inputs all add micronutrients such as phosphorus, major ions such as chloride and potassium and in the case of highway and parking lots, run off oils and heavy metals. Emissions from motorized vehicle, industries and other sources produce a variety of compounds that affect water chemistry (Goldman and Horne, 1994).

Studies of the physical and chemical hydrology of water bodies in Nigeria (both lotic and lentic) have received a great deal of attention. Some contributors include; Adedokun, *et al.*, (2008), Mustapha (2008), Onwughuta-

Enyi, *et al.*, (2008), Adeyemo *et al.*, (2008), Davies, *et al.*, (2009), Onyeama, *et al.*, (2010), Offem, *et al.*, (2009), Omoigberale and Ogbeibu (2007), Olajire and Imeokparia (2001) and Imoobe and Oboh (2003). The five rivers reported in this study (Okhuaihe, Ogba, Ikpoba, Ossiomo and Siluko) are important rivers to riparian and neighboring communities in Benin City and its environs. They are used as sources of drinking water as well as major route for transportation of goods for commercial and industrial purposes.

This study is aimed at determining

1. The extent of impact of human activities on the water quality of the rivers
2. Determine the suitability of the water for drinking purpose
3. Compare physico-chemical conditions in the rivers and compliance within permissible limits of established standards
4. Suggest possible solution in the event of pollution that may pose public health hazard.

## STUDY AREA

Benin City, the capital of Edo State, is a city in the Southern part of Nigeria and located between latitude 5°30'N and longitude 5°30'E, 6°00'W. The city is a major nexus between south eastern and south western Nigeria. The Rivers studied include; Okhuaihe, Ikpoba,

Ossiomo, Siluko and Ogba. The climate is primarily Tropical Rainforest type characterized by two main seasons, the dry season (November to April) and wet season (May to October) with a dry, windy and hazy harmattan interlude in December and January.

Station I (River Okhuhaiha) is a small pristine stream located at the outskirts of the city (about 15km from the city center) along the Benin-Asaba highway. There are rocks at the river bank and the fringing vegetation was predominantly made up of *Fimbristylis dichotoma* (sedge) and *Naja pectinata*. Station II (River Ikpoba) flows through Benin City and samples were collected at a point along the Benin-Agbor Road axis. The dominant vegetation along the bank of the river at this station was *Panicum maximum*. A lot of human activities like bathing and washing (cars, rugs and agro-products) were common features here. Station III (River Ossiomo at Ologbo) located about 25km from the city center along the Benin-Warri highway. The dominant aquatic macrophytes in this station were *Eiichornia crassipes* and *Vossia cuspidata*. Station IV (River Siluko) is situated at Ovia South-West Local Government Area in Benin City. Active fishing and commercial activities were observed at the time of sampling and the river serves as the major source of water for the surrounding communities. Station V (River Ogba) is a tributary of the Ikpoba river; sample were collected at the Airport road end of Benin city (about 5km from the city center). The stream had a fringing vegetation of mainly *Crytosperma senegalense* and *Dryopteris fillix-max* (fern).

## MATERIALS AND METHODS

Water samples were collected from the five sampling stations at monthly interval from December 2001 to July 2002. Pre washed one-liter plastic containers earlier rinsed with distilled water then with the sample to be collected were used for sample collection. Conductivity, pH and total dissolved solids (TDS) were recorded using a HACH portable digital meter. Turbidity values in NTU (Nephelometric Turbidity Units) were read off from spectronic 21D spectrophotometer (Milton Roy) at room temperature. Dissolved Oxygen was determined titrimetrically by the alkali – azide modification of Winkler's method. Alkalinity, nitrate, sulphate, phosphate, silica, Calcium and Magnesium concentrations were determined as described in APHA (1998).

Mean and standard error for each parameter were calculated for the various sampling stations, while one way analysis of variance was computed to know the level of significant difference among the stations. The physico-chemical parameters were subjected to Pearson's correlation analysis to investigate the level of interaction between the variability of the parameters with the aid of SPSS statistical software.

## RESULTS

The range, mean and standard error values of physico-chemical properties of the five rivers are summarized in table 1.

Figure 1 shows monthly variability of turbidity and pH in the five rivers. Both parameters were significantly different in the water bodies at  $P < 0.001$  and  $P < 0.05$  respectively. Minimum recorded values for both turbidity (0.5 NTU) and pH (5.1) were recorded in Okhuhaiha River while maximum value of 19.8 NTU was recorded in Ikpoba River. The least mean turbidity was also recorded in Okhuhaiha River ( $2.46 \pm 0.53$  NTU) and the highest mean value ( $12.39 \pm 1.65$  NTU) was recorded in Ossiomo River. Recorded pH values varied from minimal range of 5.1 to 6.1 (Okhuhaiha River) to maximum range of 5.7 – 7.2 (Siluko River) and the minimum and maximum mean values corresponded with both rivers too ( $5.56 \pm 0.11$  and  $6.31 \pm 0.17$  for Okhuhaiha River and Siluko River respectively).

Monthly variations in conductivity and dissolved oxygen (DO) are shown in figure 2 and there was no significant difference in both parameters ( $P > 0.05$ ) in the water bodies studied within the period of sampling. Conductivity values varied from a minimum range of  $26 - 68 \mu\text{Scm}^{-1}$  in Siluko River and maximum range of  $46 - 85 \mu\text{Scm}^{-1}$  recorded in Ogba River. Dissolved oxygen concentrations in the rivers ranged from  $3.2 \text{ mg l}^{-1}$  in Ossiomo River to  $10 \text{ mg l}^{-1}$  in Ikpoba River. DO values fluctuated remarkably in all the stations as shown by the trend in the mean DO values. The lowest mean DO values were reported in Ikpoba and Ogba rivers ( $6.25 \pm 0.72 \text{ mg l}^{-1}$  and  $6.25 \pm 0.56 \text{ mg l}^{-1}$  respectively; while highest mean DO value was recorded in Ossiomo River ( $7.35 \pm 0.52 \text{ mg l}^{-1}$ ).

Values of total dissolved solids (TDS) and nitrate fluctuated in the five rivers throughout the period of study (figure 3) and there was no significant difference in TDS ( $P > 0.05$ ) among the sampled rivers whereas nitrate content of the rivers was significantly different ( $P < 0.05$ ). The highest value of  $45.0 \text{ mg l}^{-1}$  was recorded in Station III in May. The lowest value of  $10.00 \text{ mg l}^{-1}$  was recorded in Station IV ( $P > 0.05$ ). Nitrate values fluctuated in all the stations. The highest value of  $0.14 \text{ mg l}^{-1}$  was recorded in Siluko River while the lowest value of  $0.2 \text{ mg l}^{-1}$  was recorded in Ogba River. Mean nitrate content varied from  $0.041 \pm 0.005$  to  $0.097 \pm 0.009 \text{ mg l}^{-1}$  in Ogba and Siluko rivers respectively and were significantly different ( $P < 0.001$ ).

Fluctuations in sulphate and phosphate concentrations of the sampling stations are shown in figure 4. While the sulphate content values of the rivers were highly significant ( $P < 0.001$ ); phosphate concentrations were not significantly different ( $P > 0.05$ ). Lowest range and mean values of sulphate ion concentration was recorded in Okhuhaiha River ( $0.02 - 0.05 \text{ mg l}^{-1}$ ; mean,  $0.037 \pm 0.004 \text{ mg l}^{-1}$ ) while the highest range and mean values were recorded in Siluko River ( $0.07 - 0.16 \text{ mg l}^{-1}$ ; mean,  $0.11 \pm 0.01 \text{ mg l}^{-1}$ ). Okhuhaiha River had the lowest sulphate concentration from December to May. There was an increasing trend in sulphate concentration from December to March in Siluko River. Phosphate concentration varied from a minimal range of  $0.11 - 0.41 \text{ mg l}^{-1}$  (mean,  $0.30 \pm 0.027 \text{ mg l}^{-1}$ ) in Ogba River to maximum of  $0.21 - 0.46 \text{ mg l}^{-1}$  (mean,  $0.33 \pm 0.03 \text{ mg l}^{-1}$ ) in Ikpoba River.

Table 1: Summary of mean value of physical and chemical parameters of five water bodies around Benin City environs

Parameters	Okhuaihe	Ikpoba	Ossiomo	Siluko	Ogba	P - Values
Turbidity ( NTU)	0.5 - 4.64 (2.465 ± 0.53)	3.74 - 19.48 (11.49 ± 2.19)	5.38 - 18.56 (12.39 ± 1.65)	2.29 - 9.14 (5.52 ± 1.90)	3.48 - 11.02 (8.34 ± 0.97)	P < 0.001
pH	5.10 - 6.12 (5.56 ± 0.11)	5.44 - 6.67 (5.93 ± 0.17)	5.21 - 6.40 (5.79 ± 0.13)	5.70 - 7.20 (6.31 ± 0.17)	5.33 - 6.25 (5.76 ± 0.13)	P < 0.05
Conductivity (µScm <sup>-1</sup> )	51 - 78 (63.75 ± 2.99)	38 - 83 (56.37 ± 6.29)	41 - 94 (53.37 ± 6.32)	28 - 68 (42.62 ± 5.18)	46 - 85 (61 ± 5.30)	P>0.05
Dissolved Oxygen (mgl <sup>-1</sup> )	4.8 - 10.00 (7.00 ± 0.59)	3.20 - 9.60 (6.25 ± 0.72)	5.60 - 9.60 (7.35 ± 0.52)	5.60 - 8.80 (6.7 ± 0.40)	4.8 - 9.6 (6.25 ± 0.56)	P > 0.05
TDS(mgl <sup>-1</sup> )	25.10 - 37.50 (32.13 ± 1.5)	19.40 - 41.00 (28.61 ± 2.91)	18.40 - 45.00 (29.22 ± 3.10)	15.50 - 34.00 (22.13 ± 2.60)	21.50 - 42.50 (31.21 ± 2.70)	P > 0.05
Nitrate (mgl <sup>-1</sup> )	0.03 - 0.07 (0.044 ± 0.004)	0.05 - 0.10 (0.0725 ± 0.0075)	0.04 - 0.10 (0.075 ± 0.008)	0.05 - 0.14 (0.0975 ± 0.009)	0.02 - 0.07 (0.0412 ± 0.005)	P < 0.001
Sulphate (mgl <sup>-1</sup> )	0.02 - 0.05 (0.0375 ± 0.004)	0.08 - 0.14 (0.105 ± 0.007)	0.05 - 0.12 (0.084 ± 0.008)	0.07 - 0.16 (0.11 ± 0.010)	0.03 - 0.17 (0.090 ± 0.015)	P < 0.001
Phosphate (mgl <sup>-1</sup> )	0.21 - 0.46 (0.33 ± 0.030)	0.19 - 0.44 (0.301 ± 0.027)	0.13 - 0.42 (0.32 ± 0.03)	0.14 - 0.52 (0.36 ± 0.04)	0.17 - 0.41 (0.302 ± 0.03)	P > 0.05

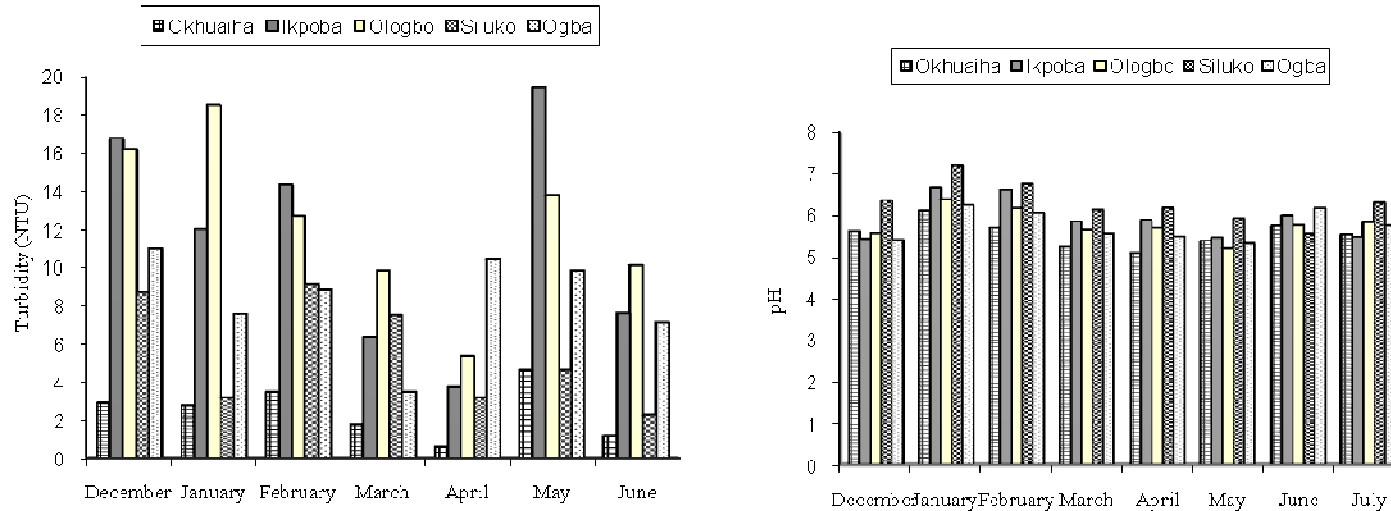


Fig. 2: Monthly variation in turbidity and pH

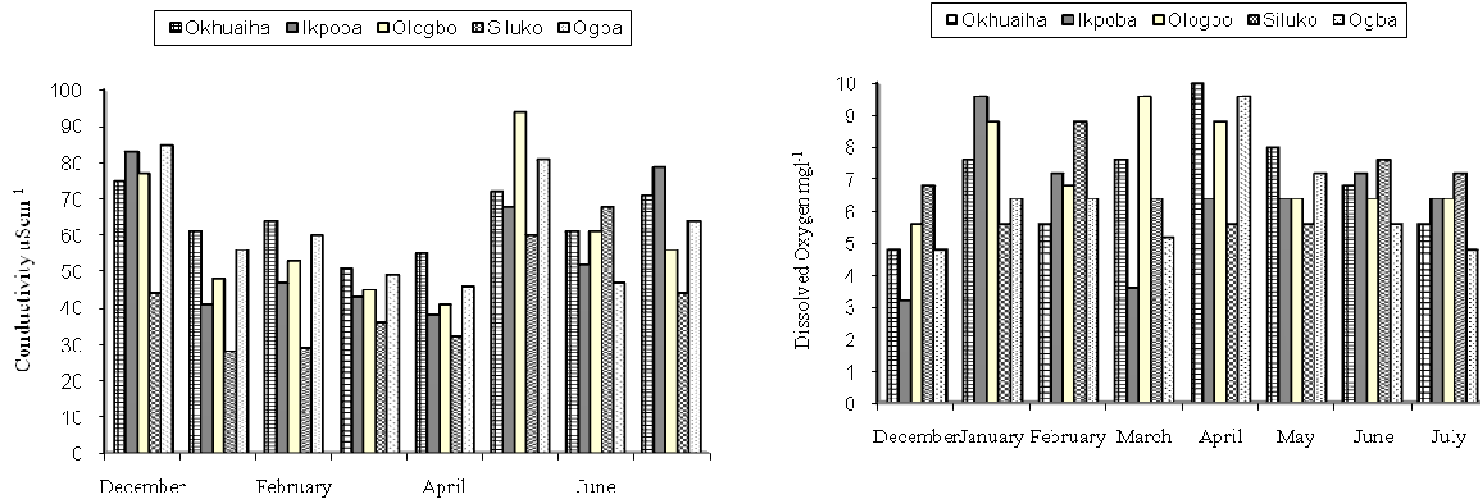


Fig. 3: Monthly variation in conductivity and dissolved oxygen

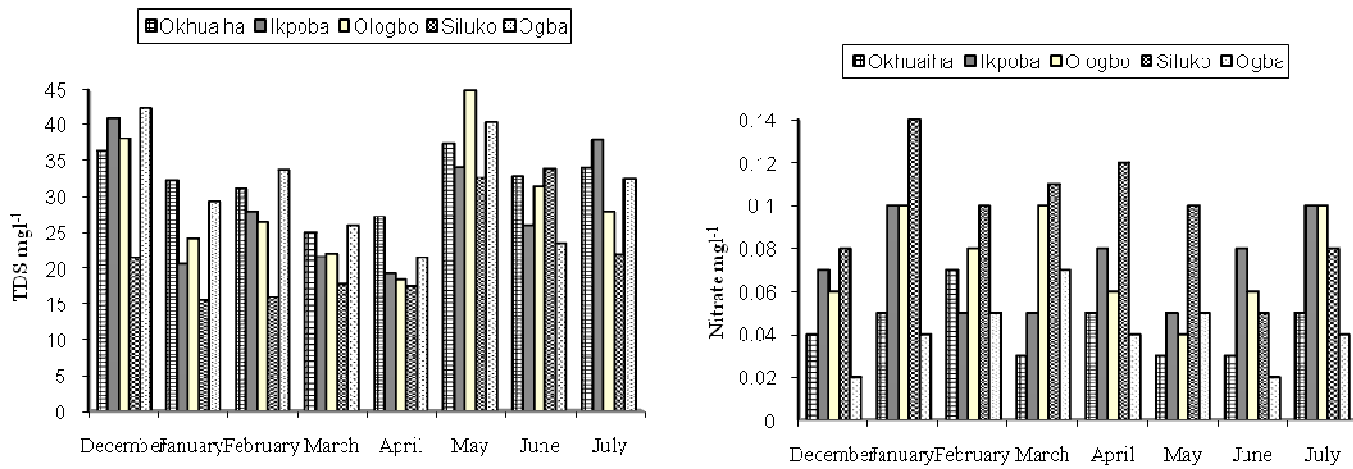


Fig. 4: Monthly variation in total dissolved solids and nitrate

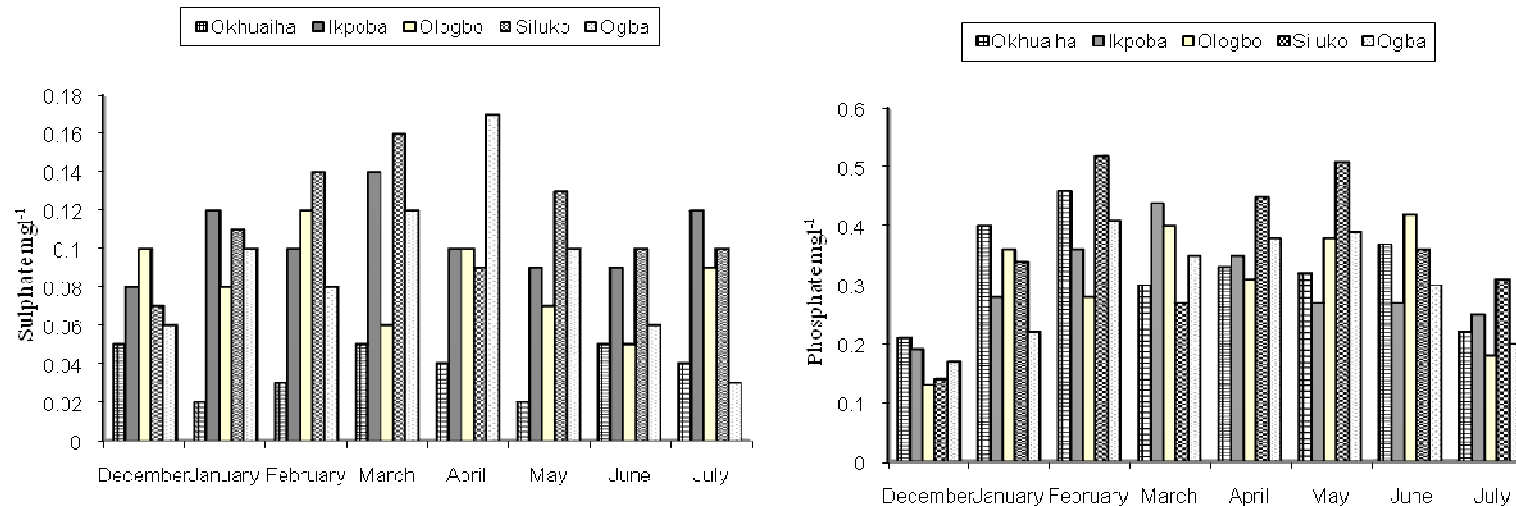


Fig. 5: Monthly variation in sulphate and phosphate

## DISCUSSION

Quantitative physico-chemical data are critical to understanding water bodies and monitoring of changes in water quality owing to intrinsic and extrinsic factors. Most of the parameters remained within the limit for most tropical waters (John, 1986) and within permissible limits (WHO, 2006; FEPA, 2008) and therefore indicative of low domestic, industrial and agricultural discharges into some of the rivers especially Okhuaiha, Ossiomo and Ogba Rivers. This could also be more of a reflection of the conditions at the time of sampling and may not possibly serve to project a general picture over an extended period of time. With the exception of pH, turbidity, nitrate and sulphate, all other parameters were not significantly different ( $P > 0.05$ ). The weak acidic pH values (mean minimum and maximum ranging from  $5.56 \pm 0.11$  and  $6.31 \pm 0.17$  for Okhuaiha River and Siluko River respectively) indicated good conditions for natural river water system, favorable and suitable condition for optimal survival and growth of fish (FEPA, 2008). Comparable values were reported by Imoobe and Oboh (2003) and Davies *et al.*, (2009) for Jamieson River (a tributary of Ossiomo River) and Minichida stream respectively. According to Holden and Green (1960) acidic waters are typical of African waters

and low pH values may be partly due to high content of humic acid in the groundwater (Olajire and Imeokparia, 2001); which may not be the case in the present study.

Electrical conductivity is a valuable indicator of the amount of materials dissolved in water, while total dissolved solids (TDS), indicates the general nature of water quality in terms of both filterable and non-filterable components of water. The mean values ( $42.62 \pm 5.18 \mu\text{Scm}^{-1}$  –  $63.75 \pm 2.99 \mu\text{Scm}^{-1}$  and  $22.13 \pm 2.59 \text{mg l}^{-1}$  –  $32.12 \pm 1.5 \text{mg l}^{-1}$ ) observed for both parameters in this study fall within recommended WHO/FEPA water quality criteria but this does not eliminate the need for treatment before drinking. Conductivity and total dissolved solids were highly positively correlated (table 2) showing strong interaction between both parameters in the rivers studied. Dissolved oxygen concentrations in all rivers were appreciably high and a reflection of high standing crop of macrophytes (Tiseer *et al.*, 2008a).

It is also an indication of the level of diffusion at the surface and various forms of surface water agitation and turbulence leading to exchange of oxygen gas between the air-water interface (Omaigberale and Ogbeibu, 2007). Furthermore samples were collected from points away from obvious industrial waste discharge points usually implicated with low oxygen content owing to presence of oxygen depleting components like organic matter.

Generally, phosphate and nitrate concentrations recorded in this investigation hover around natural contents reported for surface waters (Onwugbuta-Enyi *et al.*, 2005). The result also revealed a negative correlation between the anions (nitrate and phosphate)

and the two parameters that were positively correlated (conductivity and TDS) (table 2). This means that the concentrations of both nitrate and phosphate decreased as total ionic concentration and dissolved solids increased thus underscoring the role of these anions in the overall ionic composition of the rivers. This could have been better corroborated if only total hardness was measured. Low sulphate values have also been reported for some Nigeria rivers (Omaigberale and Ogbeibu, 2007). This report is however, at variance with the sulphate value observations for Ona river, Ondo State (Adefemi and Awokunmi, 2010).

Table 2 Pearson's correlation coefficient of physico-chemical parameters

	pH	Cond	DO	TDS	Nitrate	Sulphate	Phosphate
pH	1.000						
Cond	.295	1.000					
DO	-.537	.131	1.000				
TDS	.363	.993	.037	1.000			
Nitrate	-.618	-.824	.194	-.877	1.000		
Sulphate	.097	-.710	-.486	-.702	.667	1.000	
Phosphate	-.349	-.814	.095	-.793	.511	.186	1.000

\*\* Correlation is significant at the 0.01 level (2-tailed).

## CONCLUSION

The data presented here are comparative and provide necessary fundamental information on physical and chemical parameters, necessary for assessment of the impact of changes within the respective river basins in the future. Collection of systematic biological data on biodiversity using replicable, quantitative methods are recommended to provide the foundation for comprehensive studies that will be performed in order to better understand and manage aquatic resources in a sustainable manner. The findings of this study therefore show that the five rivers investigated under the period were oligotrophic in nature with acidic pH and fluctuating physico-chemical conditions without obvious seasonal pattern of variability.

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