

Studies on the Physico-chemical Parameters of the fresh water segment of the Lower Cross River System, South Eastern Nigeria.

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Abstract: The physico-chemical characteristics of the Lower Cross River system was determined fortnightly at two stations (Itu bridge-head and Akpamfrukim) over a period of 12 months (Jan. – Dec., 2014) using standard procedures. Parameters changed mainly in response to the seasonal regimes of meteorological events such as rainfall. Some attributes showed high dry season levels with respect to water temperature; transparency; conductivity; TDS; free CO₂; total alkalinity; NH₄-N; PO₄-P; NO₃-N; SO₄²⁻; salinity and silicate. 1.2 mg l⁻¹ of free CO₂ was commonly recorded at the two stations as its lowest with the peak (2.71mg l⁻¹) at station 1; while SO₄²⁻ and salinity was devoid at times (Aug. – Sept. and July – Sept., respectively) in station 1. Zero levels were also recorded in station 2 for salinity between August – September with seasonal significant difference (t=1.964, P<0.05) while seasonal significant difference in station 1 (t=4.699, P<0.001) and station 2 (t=4.002, P<0.01) were recorded for NO₃-N. NH₄-N also recorded a significant difference (t=5.802, P<0.05) at station 2.

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1. Introduction

The interaction of both the physical and chemical properties of water plays a significant role in the composition, distribution and abundance of aquatic organisms. The chemical substances found in water have effect on the biological processes which lead to interconversion of energy, production of organic materials and ultimately to production of aquatic resources such as fishes and other biological components found in ecosystem (Ekwu and Sikoki; 2005).

The physical and chemical limnology of a river is characterized by hydrologic impact, autogenic nutrient dynamics and biological aspect. These factors combine with each other to determine the water quality (Boland and Griffilts; 1996; Wetzel, 2001).

Though some works have been done on the Cross River system by Akpan (1998;1999; 2000), Moses (1999), Akpan *et al.*, (2002), Ekpo *et al.*, (2003), Akpan (2005), and Ekwu and Sikoki (2005), there are still some gap in information on the physico-chemical characteristics particularly of the Bridgehead and Akpamfrukim. The present study is designed to evaluate variations in the physico-chemical characteristics of the fresh water segment of the Lower Cross River system.

2. Material and Methods

Study Area

The Cross River is formed from the western slopes of Cameroon highland with the main channel 600km² from the source to the mouth (Teugels *et al.*, 1992). The main river that enters Nigeria from Cameroon follows a western direction and turns southwards to enter the Atlantic Ocean. The Upper Cross River is characterized by the absence of any well-developed flood plains and the presence of numerous ecological and geographical importance, high gradients streams, creeks and waterfalls. The river rapids are thrown progressively into stronger meander in its lower course giving rise to a number of small lakes mainly found between Obubra and Ikot Okpora, and vast floodplains downstream (Teugels, *et al.*, 1992).

The Lower Cross River is usually full to its banks at 7m depth (Akpan, 1998) and in June excess water usually inundates low-lying adjacent flood plains. The medal approval discharge value is within the range of 170 – 913m²/s (Lowenberge and Kunzel, 1999). The main channel of the river has a width range which is usually 300 – 600m.

The study area is characterized by a single dry season (October – March) and a single wet season (April – September) when 82.6% of precipitation occurs (Lebo, 2001). A single annual interruption of rainfall during the wet season occurs usually in July or August, lasting for about 2 weeks (August ‘drought’) (Akpan and Offem, 1993). During the wet season South West Trade Winds prevail which bring

high rainfall and reduced temperature prevalence (Akpan and Offem, 1993). The Cross River basin occupies an area of 54,000km², 40, 000km² with

Nigeria and 14,000km² within Cameroon (Lebo, 2000) (Fig. 1).



Fig. 1: Map of the study area

Samples collection

Water samples were collected fortnightly from two main locations of the Cross River (Bridgehead and Akpamfrukim), from January, 2014 to December, 2014. Samples were collected using 2 – litre plastic containers from 0.4m depth, during mid-morning hours. Water samples for laboratory analysis were preserved at 4°C in refrigerator and analyses were performed within 24 hours of collection.

Some parameters were measured *in situ*: water temperature was measured by 2-3 minute immersion of 0-50°C mercury in glass thermometer; pH values were measured using Horiba pH meter (model H-

71D); transparency was by the use of a 25 cm diameter Secchi disc; conductivity was measured using Hanna multi range conductivity meter (model HI 8033) and DO was measured using Lurton Do meter. The battery operated meters were calibrated according to manufacturer's instructions before being used for measurement.

In the laboratory TSS and TDS were measured by filtration, evaporation and weighing method (APHA, 1998); CO₂, total alkalinity and salinity was measured titrimetrically (APHA, 1998); BOD and COD was determine by five day incubation method (APHA, 1998) and standard methods (Wetzel and

Lekens, 1991), respectively. Other parameters such as THC, NO₃ – N, Phosphate, Silicate, NH₄-N were measured spectrophotometrically (APHA, 1998).

Data Analysis

Analysis of variance was used to test for mean spatial variation for each station; while mean seasonal variation was determined using t-test.

3. Results / Discussion

Water Temperature: The annual mean temperature for each station showed that temperature varied within narrow limits with no significant difference. Temperature in both stations 1 and 2 ranged from 26°C – 32°C, with both the peak and lowest temperature value recorded in station 2. This range is normal in the tropics (Akpan 1999) and is attributed to weather conditions of the study area – which is characterized by hot dry season and cold wet season (Moses, 1987; Akpan, 1999). Wet season, (Lebo 2001) was usually characterized by heavy cloud cover and the moist laden South West Trade Wind from Atlantic Ocean which brought about reduction in solar radiation and temperature. This might account for the low variable temperature that was noticed during the wet season in the study area. In contrast, during the dry season the dominant influence was that of the North – East Trade Wind which usually blows across the Sahara desert and consequently brings about elevated temperature (Akpan, 1999).

Transparency: The mean transparency in the dry season was higher than that of the wet season with significant difference recorded only in station 2 ($t=5.444$, $P<0.01$). Low wet season values were attributed to input of turbid material via surface run-off water and rainfall. This trend was also observed by (Ekpo *et al.*, 2003).

pH: Variation in pH was very conservative and there was no distinct peak in the two stations of the river segment. The values were within the WHO (6.50-8.50) normal range for fishing (Ekpenyong, 2005). The high concentration of pH in the wet season might have been as a result of bacterial decomposition of large amount of organic matter washed into the water by rainfall (Obire *et al.*, 2003).

Conductivity: Concentration of conductivity ranged between $8.5\mu\text{Scm}^{-1}$ (station 1) – $27.2\mu\text{Scm}^{-1}$ (station 2). High concentration (dry season) values coincided with that of TDS. The high TDS values during the dry season may be the reason for high values of conductivity. This was also observed by Rodia (1995) and Kibira *et al.* (2000). Precipitation, fresh water discharge and low temperature in the wet season do not favour high TDS concentration hence low conductivity (Khattal *et al.*, 2005).

Total Suspended Solids (TSS): Concentrations ranging between 75.80 – 140.30 mg l^{-1} were recorded with increased in the wet season and decrease in the dry. This might be caused by the wet season surface run-off water rich in turbid materials (Ekpenyong, 2005).

Total Dissolved Solids (TDS): TDS Exhibited the same trend of seasonality with water temperature recording high values during dry season and low wet season values. This could be attributed to low temperature of the wet season, which promoted poor dissolution of solute in water, and high temperature as well as low precipitation in the dry season. Ekpenyong (2005) observed high TDS levels in the dry season when compared with the wet season. This explains increase in solubility at high temperature.

Free Carbon dioxide (FreeCO₂): Low wet season values and high dry season values were traceable to increased temperature values which influenced the putrescible organic matter degradable by microbial metabolism (Akpan and Offem, 1993). Significant differences, $t=3.217$, $P<0.05$, was recorded between the two stations.

Total Alkalinity: Peak concentrations were recorded in the dry season and values in the dry season were higher than those recorded in the wet season. Significant seasonal difference was recorded only in station 2 ($t=1.443$, $P<0.05$). This seasonal trend is in line with conductivity and salinity suggesting limiting role of fresh water discharge into the water body (Chindah and Braide, 2003). Relative increase in alkalinity, conductivity and salinity in the dry season were possible due to extended dry period, high evaporation and more intrusion of sea water during the prevailing period.

Dissolved Oxygen (DO): DO showed inversed variation with water temperature during the study with high values in station 1. The lowest concentrations were recorded in March (fig. 2) with significant difference observed in station 2 ($t=-2.2777$, $P<0.05$). The high wet season values may be attributed to effect of temperature on solubility of O₂ which increases at lower temperature and decreases at high temperature (Silver and Schiemer, 2000; Van Ginkel, 2001; Mustapha and Omotosho, 2005).

Biochemical Oxygen Demand (BOD): Annual mean concentration was lower in station 1 than in station 2. Both stations showed low values during wet season while dry season was characterized by high values. This might be as a result of increased temperature which had influence on the solubility of O₂ and degradable organic matter as was observed by Odukuma and Okpokwasili (1996) in the New Calaba River.

Chemical Oxygen Demand (COD): Variation showed high values during wet season and low

values during dry season with peak concentrations recorded in the mid rainy period, depicting influence of surface run-off carrying materials that promote COD concentration (Odukuma and Okpokwasili, 1996). Significant seasonal difference was recorded only in station 2 ($t=-3.783$, $P < 0.05$). COD and TSS showed similar seasonal trend of variation.

Nitrate-Nitrogen ($\text{NO}_3^- \text{N}$): Concentrations ranged from 98.40 mg l^{-1} (station 1) to 168.90 mg l^{-1} (station 2) with significant difference in both stations 1 ($t=4.699$, $P < 0.01$) and 2 ($t=4.002$, $P < 0.01$). Values variations were similar with $\text{PO}_4\text{-P}$, showing high dry season levels and low wet season levels; suggested to be caused by fresh water discharge introduced into the river system during the rainy season which diluted nitrate concentrations.

Ammonium-Nitrogen ($\text{NH}_4 - \text{N}$): Values were high in the dry season with significant difference in station 2 ($t=5.802$, $P < 0.05$). This was due to the increase in temperature values which had influence on putrescible organic matter degradable by microbial metabolism; seasonality in $\text{NH}_4 - \text{N}$ was similar to water temperature.

Phosphate-Phosphorus ($\text{PO}_4 - \text{P}$): Concentration peaked at the onset of the rainy season (fig. 4) but the mean concentrations for the dry season was higher than that of the wet season with no significant seasonal difference recorded. Mustapha and Omotosho (2005) suggested that evaporation – crystallization process in the dry season as well as fresh water discharge into the river system in the rainy season may be the reason for the high dry season values.

Sulphate (SO_4^{2-}): High dry season values were recorded with peak concentration in February (station 1) and January (station 2). August and September recorded no values in station 1 while station 2 did not show absence of sulphate in any month during the study. The trends of Sulphate concentration were in line with that of nitrate. Massive discharge of fresh water into the system during the rainy season was responsible for decreased concentration in the values during the wet season, while evaporation – crystallization process and low fresh water discharge into the system was observed to be responsible for increase values in Sulphate concentration during the dry season.

Silicate: Maximum values were encountered in the dry season. The low concentrations observed especially during the peak rainy season may be attributed to direct dilution from rainfall. The low content of silicate in the stations monitored may be directly attributed to the geology of the places. Sedimentary rocks, which are the dominant rock type of the Cross River basin, have been associated with lowest release of silica, especially after a history of

weathering as of the case of the Cross River basin (Akpan, 1999).

Salinity: Greater water evaporation in the dry season as well as the intrusion of salty water from the estuary as a result of no rainfall discharge during the season accounted for higher dry season values and low wet season values (Ekpenyong, 2005).

Total Hydrocarbon Content (THC): Sources of THC to these stations maybe attributed to bunkering activities, oil and petroleum products discharge by fishing boats used by fishermen and other pollution activities. This situation is common to other areas in the Niger Delta (Ubon and Essien, 2003). The higher wet season values depict discharge of water during the rainy season which carries more hydrocarbons along with it.

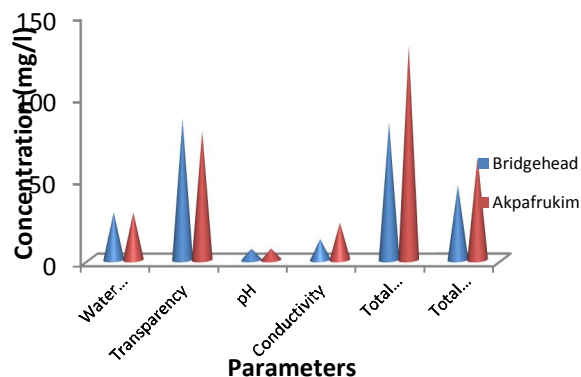


Fig 2: Mean Temporal Variation in water temperature, Transparency, pH, Conductivity, Total Suspended Solids and Total Dissolve Solids in the lower Cross River System.

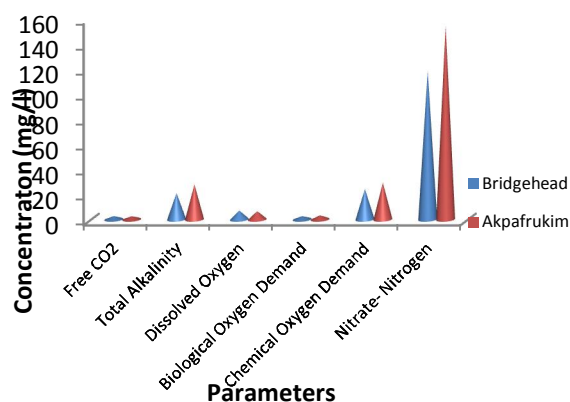


Fig 3: Mean Temporal Variation in Free CO₂, Total Alkalinity, Dissolved Oxygen, Biological Oxygen Demand, Chemical Oxygen Demand and Nitrate-Nitrogen in the lower Cross River System.

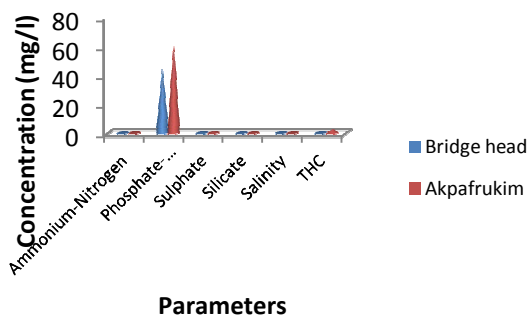


Fig 4: Mean Temporal Variation in Ammonium-Nitrogen, Phosphate-Phosphorous, Sulphate, Silicate, Salinity and Total Hydrocarbon in the lower Cross River System.

4. Conclusion

In the dry season, the rainfall receding effect and low fresh water discharge from small tributaries and creeks influenced salt intrusion to be high in the river system. High temperature of the season brought increased TDS, conductivity, free CO_2 , $\text{NH}_4 - \text{N}$ and high transparency levels. Increased salinity as a function of evaporation – crystallization process as well as dilution by fresh water discharged. Poor solubility at increased temperature was observed to cause the low DO of the season.

Massive discharge of fresh water into the river system in the wet season diluted SO_4^{2-} and $\text{NO}_3 - \text{N}$. Strong wind actions and reduction in temperature increased the solubility of DO while increased precipitation and input of surface run-off increased the levels of THC, TSS, COD and turbidity (low transparency). High pH in the season was caused by decomposition of large amount of nutrient load, probably rich in carbonate, washed into the water by rainfall.

Though the physico – chemical parameters studied were within the permissible limit for fishing, constant monitoring of the river system is advisable since the system can be significantly altered by any form of natural dynamics and anthropogenic activities which may consequently affect the balance of the ecological system.

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