# Factor Analysis And Physico-Chemical Characteristics Of Calabar River, Southern Nigeria

Andem, Andem Bassey, Okorafor, Kalu Ama, Ekanem, Sunday Ben

**Abstract**: Factor analysis were applied to investigate the most distributed and valuable factor as regards water quality parameters of Calabar River. Four sampling station were chosen along course of the River. Samples were collected monthly from January to December, 2013 usually between 7:00am to 10:00am. The physico-chemical parameters investigated in each case were surface water temperature, pH, dissolve oxygen (DO), biochemical oxygen demand (BOD), conductivity, total dissolved solids (TDS), total suspended solids (TSS) and heavy metals, all from surface water. The result of this study shows that Conductivity, TDS and TSS recorded for high positive loading of 0.641, 0.873 and 0.836 respectively for the first component while in the second component high positive loading of 0.751 and 0.639 were recorded for DO and BOD and for third component copper and cadmium recorded for high positive loading of 0.657 and 0.522 respectively during the dry season. During the wet season, high positive loading of 0.912, 0.864, 0.806, 0.786, 0.755, 0.666, 0.637 and 0.628 were recorded for DO, TDS, chromium, TSS, conductivity, surface water temperature , BOD and copper in the first component. pH and Iron had high positive loading of 0.737 and 0.697 respectively for second component and Lead recorded high positive loading of 0.811 for third component. The study reveal that chemical factors were more distributed and valuable than the physical factors, this means that contribution of Industrial and anthropogenic activities discharge into the River were clearly indicated by factor analysis. In other to restore our aquatic ecosystem, there is need to re-enforce environmental laws and guideline standard for effective water quality management.

**Keywords:** Factor analysis, Physico-characteristics, Calabar River, Nigeria

## 1 Introduction

River system comprises both the main courses and the tributaries, carrying the one-way of a significant load of matter both natural and anthropogenic sources [1]. Rivers are heterogeneous at different spatial scale which may be attributed to a number of factors including anthropogenic input, biomass characteristic, soil erosion, weathering of crustal minerals, local environmental conditions, water discharge, water velocity and degree of surface water chemistry [2]. On the other hand, rivers play a major role in assimilation or transporting municipal and industrial wastewater and runoff from agricultural land. Municipal and industrial wastewater discharge constitutes a constant polluting source, whereas surface runoff is a seasonal phenomenon, largely affected by climate within the basin [3]. The application of different multivariate statistical techniques, such as principal component analysis (PCA) and factor analysis (FA), helps in the interpretation of complex data matrices to better understand the water quality and ecological status of the studied systems, allows the identification of possible factors/ sources that influence water systems and offers a valuable tool for reliable management of water resources as well as rapid solution to pollution problems [4].


- *Andem, Andem Bassey is currently a lecturer in the University of Calabar, Calabar, Department of Zoology and Environmental Biology, Cross River State, Nigeria PH:+2348060168081.*
  *E-mail: andem1120unical@yahoo.com*
- *Okorafor Kalu Ama is currently a lecturer in the University of Calabar, Calabar, Department of Zoology and Environmental Biology, Cross River State, Nigeria.*
- *Ekanem, Sunday Ben is a professor of Fisheries and Aquaculture in the University of Calabar, Calabar, Department of Zoology and Environmental Biology, Cross River State, Nigeria.*


Multivariate statistical techniques has been applied to characterize and evaluate surface and freshwater quality, and it is useful in verifying temporal and spatial variations caused by natural and anthropogenic factors linked to seasonality [5]. Therefore, the effective, long-term management of rivers requires a fundamental understanding of hydro-morphological, chemical and biological characteristics. However, due to spatial and temporal variations in water quality (which are often difficult to interpret), a monitoring program, providing a representative and reliable estimation of the quality of surface waters, is necessary [1]. This research work was aimed at investigating the most important and distributed factor as regards water quality parameters of Calabar River using principle component analysis.

## 2 MATERIALS AND METHODS

### 2.1 Description of Study Area

Calabar River flows from the northern part of the city of Calabar joining the southern at about eight kilometers. This River forms a natural harbour deep enough for vessels with a draft of six (6) meters. The River drains from part of Oban hills in the Cross River National Park [6] with the longitude of $8^0$18’E and latitude of $4^0$58’3N [7]. The basin of the River is about 43 kilometers wide and 62 kilometers long, with an area of 1,514 square kilometers [8]. The region has a wet season from April to October, with about 80% of the annual rain falls, with peak of the rainfall in June and September. The River have annual rainfall average of about 1,830 millimeters, average temperature range from $24^0$C ($75^0$F) in August to $30^0$C ($86^0$F) in Feburary. The relative humidity of the River is high between 80% and 100% [8]. The basin of the River has about 223 streams with a total length of 516 kilometers, this is a small number given the size of the basin. The drainage system in Calabar is poor, so the basin is subjected to gully erosion, flooding and landslides, infact a 2010 study said that flood had increased in recent years [8].

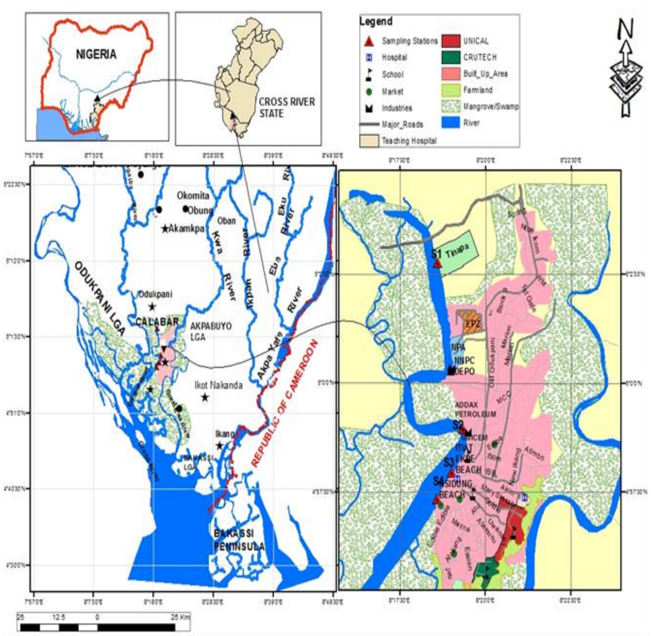


***Figure 1:*** *Map of Nigeria showing major water bodies and Calabar River with sampling stations (1-4)*

### 2.1.1 Sampling Stations
Four stations (1-4) were chosen along the shoreline of the River. Co-ordinates and appropriate distances of each station were taken and calculated using Geographic Positioning System (GPS).

**Station One (S1)**
It is coastal water which flows behind Africa's first ever free trade zone which is also a tourist destination with a serene environment; it is an upstream station which serves as a control point. This station is assumed to be unpolluted since the wastes which flow into the river from this point is very minimal. The water channels is clean, very little activity occurs at the river banks and fishing activities is restricted for security reasons. The station is located at Tinapa Resort Beach between Latitude: N $5^0$ 02' 820''; Longitude: E $8^0$ 19' 16'' at 23 feet altitude.

**Station Two (S2)**
Station 2 is the first discharge point, it receives effluents from shipping activities, off-loading of finished petroleum product from ship to pipelines; fishing activity is minimal and some of the industrial wastes are also drained into the river. This station is located at Addax Petroleum Company between Latitude: N $4^0$ 58' 988"; Longitude: E $8^0$ 16' 872" at 24 feet altitude.

**Station Three (S3)**
This station is the second discharge point, it consists of linear settlement across the river bank were fishing activities predominate; ships and boats also anchor along this beach. The Station is located at Itiat Ekpe Beach between Latitude: N $4^0$ 32' 124''; Longitude: E $8^0$ 16' 872 '' at 42 feet altitude.

**Station Four (S4)**
This station is a commercial station with a large market located at the bank of the River. Anthropogenic wastes from this station also empty into the River. This is a landing site for fishermen and distribution to other stations. This station is located at Nsidung Beach between Latitude: N $4^0$ 57' 326''; Longitude: E $8^0$ 18' 557'' at 26 feet altitude.

## 2.2 Physico-chemical parameters
Samples were collected monthly from January to December, 2013 at four different stations usually between 7:00am to 10:00am. The physico-chemical parameters investigated in each case were surface water temperature, pH, dissolve oxygen (DO), biochemical oxygen demand (BOD), conductivity, total dissolved solids (TDS), total suspended solids (TSS) and heavy metals, all from surface water.

### 2.2.1 Surface water temperature
In each sampling station, temperature of the River was measured with a mercury-in-glass thermometer which was inserted to the depth level of the water of about 2cm from surface for 3 minutes. The readings were expressed in degrees Celsius ($^0$C).

### 2.2.2 pH
The pH was measured insitu using pocket pH meter (pH 1 model). The probe of the meter were dipped into the water sample and the pH read as recommended by [9].

### 2.2.3 Dissolved oxygen (DO) and Biological oxygen demand (BOD)
Dissolved oxygen was measured *in situ* with DO meter (Model DO–5509) and the water sample were taken to the Post graduate laboratory, Department of Zoology and Environmental Biology and incubated for five days at 20$^0$C, after five days the reading was taken. The first day DO minus the fifth day DO ($DO_1$- $DO_5$) gives the BOD.

### 2.2.4 Conductivity, Total dissolved solids (TDS) and Total suspended solids (TSS)
In the laboratory, Conductivity, TDS and TSS were measured using Hannah Instrument (Bench meter 211 model). Different probe of the meter for each parameters were immersed in the water samples collected, each parameters such as conductivity, TDS and TSS were read off as recommended by [9].

## 2.3 Metal Analysis
Heavy metals were determined by digesting 250ml of water samples with 10ml analytical grade nitric acid to acidify it, the solution was evaporated on a crucible to approximately 25ml then filtered into a standard flask and diluted with distill water [10]. The mixture was gently heated in a water bath until the acid became bleached. The digested water samples were analyzed for Lead (Pb), Copper (Cu), Iron (Fe) and Chromium (Cr) and Cadmium (Cd) using the Perkin Elmer (A Analyst 200) version 6.0 Atomic Absorption spectrometry (AAS).

## 2.4. Statistical Analysis
Data obtained were subjected to factor analysis such as Principal components analysis (PCA) was used to summarize the major patterns of distribution and variation within the physico-chemical data using Predictive Analytics Software (PASW), version 20.

# 3 RESULTS

## 3.1 Factor analysis of physico-chemical parameters

Conductivity, TDS and TSS recorded for high positive loading of 0.641, 0.873 and 0.836 respectively for the first component while in the second component high positive loading of 0.751 and 0.639 were recorded for DO and BOD and for third component copper and cadmium recorded for high positive loading of 0.657 and 0.522 respectively during the dry season (Figure 2). During the wet season, high positive loading of 0.912, 0.864, 0.806, 0.786, 0.755, 0.666, 0.637 and 0.628 were recorded for DO, TDS, chromium, TSS, conductivity, surface water temperature (SWT), BOD and copper in the first component. pH and Iron had high positive loading of 0.737 and 0.697 respectively for second component and Lead recorded high positive loading of 0.811 for third component (Figure 3).

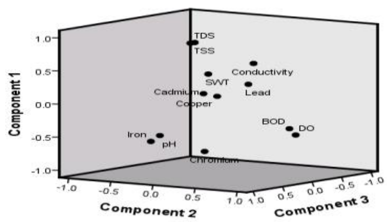


***Figure 2:*** *Principal Component Analysis (PCA) Plot of Physico-chemical Parameters for Dry Season*

Where:
SWT = Surface water temperature, TDS = Total dissolved Solids, TSS = Total suspended Soilds, BOD = Biological oxygen demand, DO = Dissolved oxygen

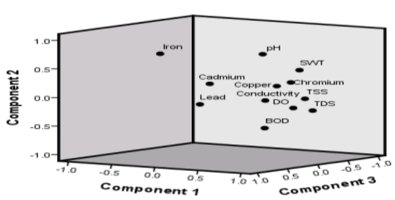


***Figure 3:*** *Principal Component Analysis (PCA) Plot of Physico-chemical Parameters for Wet Season*

Where:
SWT = Surface water temperature, TDS = Total dissolved solids, TSS = Total suspended solids, BOD = Biological oxygen demand, DO = Dissolved oxygen

# 4 DISCUSSION

Some rivers receive water from drainages or channels with respect to their sizes, therefore vulnerable to changes in the quality of water [11]. Factor analysis of the physico-chemical parameters study in Calabar River shows differences in the most important factor between the two seasons. The result of this study shows that during the wet season, dissolved oxygen, total dissolved solids, chromium, total suspended solids, conductivity; surface water temperature, biological oxygen demand and copper were recorded for high positive loading in the first component. The most important factor in wet season could be regarded as ionic and chemical factor. The pH and iron were recorded for high positive loadings in the second component; this component can therefore be referred to as physical or chemical factor. Lead recorded positive loadings on the third component and can therefore be regarded as chemical factor. However, factor analysis for the wet season was able to separate the physical variable from the chemical variable suggesting that chemical variables are most important than physical variables in wet season. For the dry season, conductivity, total dissolved solids and total suspended solids were recorded for high positive loadings for the first component, which could therefore be regarded as chemical factor. Dissolved oxygen and biological oxygen demand also recorded high positive loadings for the second component and therefore could also be regarded as chemical factor. Copper and cadmium recorded positive loadings in the third component and can also be regarded as chemical factor. [12] Reported significant difference for parameters between seasons as indication of change in water quality during his study. Annually both physical and chemical parameters, dissolved oxygen, total dissolved solids, chromium, total suspended solids, conductivity; surface water temperature, biological oxygen demand and copper recorded, have high positive loading on the first component, this could be regarded as the nutrient factor. Therefore, pH, conductivity, surface water temperature, dissolved oxygen and biological oxygen demand are important annual variables for the River.

# 5 CONCLUSION

Factor analysis (FA) was applied to investigate the most distributed and valuable factor as regards water quality parameters of Calabar River. Thus, this study illustrates the usefulness of multivariate statistical techniques for analysis and interpretation of complex sets of data, water quality assessment and identification of pollution factors. The results of this study reveal that chemical factors were more distributed and valuable than the physical factors. The contribution of Industrial and anthropogenic activities discharge into the river were clearly indicated by PCA/FA. In other to restore our ecosystem, there is need to re-enforce environmental laws and guideline standard for effective water quality management.

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