Factor Analysis on the Variability of Physico-chemical Parameters of Obutu Lake, Ndikelionwu, Anambra State

Aronu, C. O.[1*]
Department of Statistics,
Chukwuemeka Odumegwu Ojukwu University, Anambra State, Nigeria
*Email of Corresponding Author: padre4baya@gmail.com

Ekwueme, O. G.[2]
Department of Industrial Production Engineering,
Nnamdi Azikiwe University, Awka, Anambra State, Nigeria

Bilesanmi A. O.[3]
Department of General Studies,
Petroleum Training Institute, Effurun-Delta State, Nigeria

DOI: 10.31364/SCIRJ/v7.i10.2019.P1019714
http://dx.doi.org/10.31364/SCIRJ/v7.i10.2019.P1019714

***Abstract*- This study examined the variability of physico-chemical parameters at Obutu Lake, Ndikelionwu, Anambra State, Nigeria. The objective of the study was to determine the parameters that can adequately explain the variability of the physico-chemical parameters without loss of useful information. The data used in the study was obtained through secondary source. The Factor analysis and rank correlation was used to analyze the data for the study. Findings of the study revealed that inverse relationship exists among temperature and dissolved oxygen, Conductivity, alkalinity, Nitrate-nitrogen concentration, and Phosphate-phosphorus concentration while pH and transparency has positive relationship with temperature. Further result revealed that dissolved oxygen was found to have positive relationship with conductivity, alkalinity, Nitrate-nitrogen concentration and Phosphate-phosphorus concentration while transparency was found to have negative relationship with dissolved oxygen. Four factors were retained using the maximum likelihood extraction approach for the factor analysis because the factors were able to explain above 80% of total variability. Also, Phosphate-phosphorus conc., alkalinity, transparency, dissolved O2, Nitrate-nitrogen Conc. and conductivity were identified as the key physic chemical parameters that explained over 80% of the variability attributed to the model. Hence, Phosphate-phosphorus conc., alkalinity, transparency, dissolved O2, Nitrate-nitrogen Conc. and conductivity are consistent in explaining the physic chemical parameters of Obutu Lake with loss of useful information.**

Index Terms*— *Factor Analysis, Maximum Likelihood Method, variability, Parameters

Introduction

There are few literatures where the choice of using physic-chemical parameters of water bodies in evaluating the potential and quality of the water in most developing countries. Even where such data and literature exists, it is observed that such data are not utilized and they are allowed to waste [1]. More studies on water quality were as a result of the desire to protect fresh water fisheries. The water quality requirements are classified into physicochemical parameters which comprises of pH, temperature, dissolve oxygen, transparency, total alkalinity, total hardness, electrical conductivity, total dissolved matter, e.t.c.

Water quality parameters associate with their biotic components and have impact on the productive potential of fish species ([2]; [1]). The fish carrying capacity of aquatic ecosystems is a function of the biology of a particulars species and its association with its environment and other species [3].

This study, therefore, examines the variability of physic-chemical parameters of Obutu Lake, Ndikelionwu, Anambra State, Nigeria using the factor analysis approach. The objective of the study was to determine the parameters that can adequately explain the variability of the physico-chemical parameters with loss of useful information.

Literature Review

Study by [4] focused on the assessment of the physic-chemical parameters of Kontagora Reservoir in Niger State. Data for the study were analyzed using the one-way analysis of variance to test for equality of the parameters while the means were compared using Duncan's Multiple Range Test (DMRT). The result of the study revealed that there was significant variation in all the physico-chemical parameters for the seasons. However, water temperature, depth, conductivity, dissolved oxygen, water hardness, alkalinity and total dissolved solid were found to be highly significant while others factors were significant at 95% significant level. The mean dry season values of transparency (12.46m), conductivity (86.41µs) , dissolved oxygen (4.70mg/l), water hardness (56.07mg/l), alkalinity (53.38mg/l) , phosphate - phosphorus (6.86mg/1) and total dissolved solids (43.19ppm) were found to be higher than those of rainy seasons. Water temperature (27.65°c), water

depth (7.74 m), pH (7.15) nitrate - nitrogen (5.21mg/l) mean values were equally found to be higher in the rainy season than the dry season. Further findings showed that apart from water depth and dissolved solids, that showed significant difference at 95% significant level, all other parameters were found to be insignificant for all the five sampling stations considered in their study.

Study by [1] considered the physico-chemical parameters and plankton abundance in relation to fish productivity were carried out on four natural lakes in the four agricultural zones in Anambra State, Southeastern Nigeria. The data for the study were collected during the dry and wet season. The study employed correlation analysis, percentage distribution and frequency distribution in analyzing the data obtained for the study. The result obtained from the study revealed an inverse relationship between phytoplankton and zooplankton abundance. It was found that in all the four lakes, plankton density as well as physico-chemical parameters varied with the seasons, being more abundant in the rainy season. Further findings showed that there was no evidence of fisheries activities in Nwangene Lake. Fish species encountered in Nwangene Lake were found to be of no commercial importance. Potential fish yield in Agulu Lake (mean depth 5.50m) was found to be 2.32%; 3.40% from Agbu Lake (mean depth: 3.50m); 3.80% for Obutu (mean depth: 3.20m) and 9.86% for Nwangene (mean depth: 1.25m). This indicates that there exist a general trend of increasing productivity with decreasing with decreasing depth which is an illustration of the principle that biomass is not necessarily correlated with rate of production [1].

Methods and Material

Method of Data collection

Secondary source of data collection was adopted for this study with the aid of data obtained from [5]. The data comprises of mean values of temperature, pH, dissolved oxygen, transparency, Conductivity, alkalinity, Nitrate-nitrogen concentration, and Phosphate-phosphorus concentration.

Method of Data Analysis

Factor Analysis

Factor analysis (FA) is a class of multivariate statistical methods whose primary purpose is to reduce the dimension of the data of interest and provide useful inference on the variability of the data. It addresses the problem of analyzing the interrelationship among a large number of variables and then explaining these variables in terms of their common, underlying factors [6]. The FA method relates to the correlations between a large numbers of quantitative variables. It reduces the number of primary variables by calculating a smaller number of new variables, which are called factors. This reduction is achieved by grouping variables into factors by which means each variable within each factor is closely correlated and variables which belong to different factors are less correlated [7].

In the area of factors calculation, the principal components method (PCM), and the maximum likelihood method (ML), are two mostly applied techniques. If PCM is used, then the minimum average partial method can be used [8] whereas if ML is used, then fit indices can be used as described by [9]. This study will employ the maximum likelihood method.

The Method of Maximum Likelihood

The maximum likelihood method is a statistical tool which can be employed in estimating parameters for a given statistic by making the known likelihood distribution a maximum. It can also provide estimators that have both reasonable intuitive basis and many desirable statistical properties. This is because once a maximum-likelihood estimator is derived, the general theory of maximum-likelihood estimation provides standard errors, statistical tests, and other results useful for statistical inference. A maximum likelihood estimator is a measure of the parameter such that the likelihood function is a maximum.

Let observations X=(x1, ..., xn) be realized values of random variables X=(X1, ..., Xn) and suppose that the random vector X, having density with respect to some -finite measure . Here is the scalar parameter to be determined. The likelihood function corresponding to the observed vector x from the density is written as

(1)

whose logarithm is denoted by . When the Xi are iid with probability density with respect to a -finite measure .

(2)

If the parameter space is given as then the maximum likelihood estimate (MLE) is the value of maximum or equivalently its logarithm over That is,

is the log-likelihood while L is regarded as a function of with x fixed.

The number of factors to be retained is similar to the number of positive eigen values of the correlation matrix. This may, however, not always lead to the right solutions, as it is possible to obtain eigenvalues that are positive but very close to zero. Therefore, some rules of thumb have been suggested for determining how many factors should be retained [10]:

1. Retain only those factors with an eigen value larger than 1 (Guttman-Kaiser rule);
2. Is to retain the factors which cumulatively accounted for 80% or above of the variability.

It is furthermore always important to check the uniqueness of the variables after factor extraction. If the uniqueness are low, the extracted factors account for only large part of the variance, and less factors might be retained in order to provide a better account of the variance without loss of useful information.

Data Presentation

Data Analysis and Discussion

Table 1: Mean Monthly variations of Physico-Chemical Parameters in Obuto Lake from January 2016 to December 2016

Month	Temperature	pH	Dissolved O2 (mg/l)	Transparency (m)	Conductivity (mhos/cm)	Alkalinity (ppm)	Nitrate-nitrogen Conc. (mg/l

http://dx.doi.org/10.31364/SCIRJ/v7.i10.2019.P1019714

							)
Jan	28	9	5.31	1.2	41	11	0.56
Feb	28	7	3.7	2.9	38	9	0.61
Mar	27	7.2	5.35	0.8	40	10	0.63
Apr	29	8	5.15	0.8	46	12	0.72
May	31	8	5.56	0.8	52	22	0.85
June	23.1	8	5.56	1.2	61	23	0.86
Jul	23.2	8	5.7	1	71	28	0.86
Aug	24	8	5.9	0.6	56	35	0.87
Sep	23	9	6.2	0.9	48	28	0.87
Oct	26	8	6.1	0.8	48	21	0.75
Nov	28	10	5.05	0.5	45	19	0.83
Dec	27	10.2	5.09	1.5	38	12	0.61

Source: [6]

Table 2 shows the correlation coefficient of the physico chemical parameters of Obutu Lake

Table 2: Table showing the correlation coefficient of the physico chemical parameters of Obutu Lake

	Temperature	pH	Dissolved O_2	Transparency	conductivity	alkalinity	Nitrate-nitrogen Conc.	Phosphate-phosphorus conc.
Temperature	1							
pH	0.016	1						
Dissolved O_2	-0.4922	0.1561	1					
Transparency	0.1085	-0.2746	-0.7832	1				
conductivity	-0.5774	-0.19771	0.5063	-0.3433	1			
alkalinity	-0.636	0.0223	0.698	-0.4826	0.7619	1		
Nitrate-nitrogen Conc.	-0.4581	0.00081	0.5844	-0.5266	0.7707	0.8823	1	
Phosphate-phosphorus conc.	-0.6511	-0.1663	0.6552	-0.438	0.8949	0.9432	0.8723	1

The result obtained in table 2 showed that inverse relationship exists among temperature and dissolved oxygen (r=-0.4922), Conductivity (r= -0.5774), alkalinity (r= -0.636), Nitrate-nitrogen concentration (r=-0.4581), and Phosphate-phosphorus concentration (r=-0.6511) while pH (r=0.016) and transparency (r=0.1085) has positive relationship with temperature. It was found that pH has inverse relationship with transparency (r=-0.2746), conductivity (r=-0.1971), and Phosphate-phosphorus concentration (r=-0.1663) while dissolved oxygen (r= 0.1561), alkalinity (r=0.0223), and Nitrate-nitrogen concentration (r=0.0081) has positive relationship with pH. Dissolved oxygen was found to have positive relationship with conductivity (r=0.5063), alkalinity (r= 0.698), Nitrate-nitrogen concentration (r=0.5844) and Phosphate-phosphorus concentration (r=0.6552) while transparency (r=-0.7832) was found to have negative relationship with dissolved oxygen.

Table 3: Table showing Eigen Values and Cumulative Proportion

Factor analysis/correlation	Number of observations= 12
Method: maximum likelihood	Retained factors=4
Rotation: (unrotated)	Number of parameters = 26
Schwarz's BIC= 66.8211	
Log likelihood = -1.106788	(Akaike's) AIC= 54.2136

Factor	Eigenvalue	Difference	Proportion	Cumulative Proportion
Factor1	4.57912	3.97993	0.6876	0.6876
Factor2	0.59919	-0.50576	0.09	0.7776
Factor3	1.10495	0.72856	0.1659	0.9435
Factor4	0.37639	.	0.0565	1

The result obtained in table 3 found Eigen values and the proportions of the explained variance. The result revealed that four factor can be retained since they were able to explain above 80% of total variability.

Table 4: Table showing Factor loadings (pattern matrix) and unique variances

Parameters	Factor 1	Factor 2	Factor 3	Factor 4	Uniqueness
Temperature	-0.6537	0.0141	-0.2195	0.3995	0.3647
pH	-0.1096	0.5685	-0.2346	-0.0173	0.6094
Dissolved O_2	0.678	0.2035	-0.4963	-0.3954	0.0963
Transparency	-0.4599	-0.2163	0.8612	0	0
conductivity	0.8651	-0.3363	-0.0211	0.0549	0.1351
alkalinity	0.9721	0.2339	0.0174	0	0
Nitrate-nitrogen Conc.	0.8864	0.0969	-0.1139	0.239	0.1348

http://dx.doi.org/10.31364/SCIRJ/v7.i10.2019.P1019714

Phosphate-phosphorus conc.	0.9948	-0.1018	-0.003	0	0

The result obtained in table 4 showed that that the parameters that explained over 80% of the variability attributed to the model were in the following order Phosphate-phosphorus conc., alkalinity, transparency, Dissolved O2, Nitrate-nitrogen Conc. and conductivity with corresponding uniqueness values of 0, 0, 0, 0.0963, 0.1348 and 0.1351 respectively.

Conclusion

This study used the factor analysis approach to examine the variability of physic chemical parameters in Obutu Lake, Anambra State. Findings of the study revealed that inverse relationship exists among temperature and dissolved oxygen, Conductivity, alkalinity, Nitrate-nitrogen concentration, and Phosphate-phosphorus concentration while pH and transparency has positive relationship with temperature. Also, pH was found to have inverse relationship with transparency, conductivity, and Phosphate-phosphorus concentration while dissolved oxygen, alkalinity, and Nitrate-nitrogen concentration has positive relationship with pH. Further result revealed that dissolved oxygen was found to have positive relationship with conductivity, alkalinity, Nitrate-nitrogen concentration and Phosphate-phosphorus concentration while transparency was found to have negative relationship with dissolved oxygen.

Four factors were retained using the maximum likelihood extraction approach for the factor analysis because the factors were able to explain above 80% of total variability. Also, Phosphate-phosphorus conc., alkalinity, transparency, dissolved O2, Nitrate-nitrogen Conc. and conductivity were identified as the key physic chemical parameters that explained over 80% of the variability attributed to the model. Hence, Phosphate-phosphorus conc., alkalinity, transparency, dissolved O2, Nitrate-nitrogen Conc. and conductivity are consistent in explaining the physic chemical parameters of Obutu Lake with loss of useful information.

Based on the findings of this study, we recommend that future researchers at Obutu lake concentrate more on data collect about Phosphate-phosphorus conc., alkalinity, transparency, dissolved O2, Nitrate-nitrogen Conc. and conductivity since they were found to be consistent in explaining the variability of physic chemical parameters of Obudu Lake.

References

[1] M. C. Nwosu “Studies on the Physico-Chemical Parameters and Plankton Abundance in Relation to Fish Productivity in Four Natural Lakes in Anambra State, Nigeria, Southeastern Nigeria.” International Journal of Innovative Science and Research Technology, 2017, 2(8): 365-374.

[2] M. C. Nwosu “Studies on physico-chemical parameters and plankton abundance in relation to fish productivity of four lakes in Anambra State, Nigeria”. P. 205. Ph.D Thesis, Nnamdi Azikiwe University, 2003.

[3] M. C. Nwosu, A. I. Onwurah, L. C. Anyaeggunam, and K. N. Ibemenuga “Studies on the Ichthyofaunal assemblage of three eutrophic lakes in Anambra State, Nigeria.” Journal of Science, Engineering and Technology, 2012, 19(1): 10726-10737.

[4] B. U. Ibrahim, J. Auta, and J. K. Balogun “An Assessment of The Physico-Chemical Parameters Of Kontagora Reservoir, Niger State, Nigeria.* Bayero Journal of Pure and Applied Sciences, 2009, 2(1): 64 – 69

[5] M. C. Nwosu, “Studies on Physico-Chemical Parameters and Plankton Abundance in relation to fish productivity of Obudu Lake, Ndikelionwu , Anambra State, Nigeria” COOU Journal of Physical Sciences, 2017, 1(2): 105-114.

[6] J. F. Hair, R. E. Anderson, R. L. Tatham, and B. J. Grablowsky (1979). Multivariate Data Analysis. Petroleum Publishing Company.

[7] J. F. Hair, W. C. Black, B. J. Babin, R. E. Anderson “Multivariate Data Analysis,” 7th ed. Macmillan, New York, 2010.

[8] W. F. Velicer “Determining the number of components from the matrix of partial correlations.” Psychometrical, 1976, 41, 321-327.

[9] L. R. Fabrigar, D. T. Wegener, R. C. MacCallum, and E. J. Strahan “Evaluating the use of exploratory factor analysis in psychological research.” Psychol. Meth. 4, 1999, 272-299.

[10] S. I. Onyeagu “ A First Course in Multivariate Statistical Analysis.” Mega Concept publication, Nigeria, 2003.

http://dx.doi.org/10.31364/SCIRJ/v7.i10.2019.P1019714