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Assessment of Primary Productivity of Kiri Reservoir, Adamawa, Nigeria

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Abstract
Primary productivity is a fundamental ecological concept that quantifies the rate of organic matter production through photosynthesis per unit area in aquatic environments, reflecting the foundational energy conversion in biological systems. This study was conducted in Kiri Reservoir, Shelleng Local Government Area of Adamawa State, Nigeria. This study investigated the primary productivity dynamics of the reservoir by conducting a comprehensive spatial and temporal analysis. Water samples were systematically collected from four strategic sampling locations (inflow, outflow, and mid-reservoir positions) over a four-month period from October 2023 to February 2024, with statistical analysis performed using ANOVA to evaluate productivity variations. The samples were used to assess the gross primary productivity, net primary productivity, and community respiration. Gross primary productivity ranged from 0.108±0.004gCm^{-3}h^{-1} to 0.126±0.02gCm^{-3}h^{-1}, Net primary productivity ranged from 0.059±0.05gCm^{-3}h^{-1} to 0.067 gCm^{-3}h^{-1} ±0.004 gCm^{-3}h^{-1} and Community respiration ranged from 0.043±0.003 gCm^{-3}h^{-1} to 0.047±0.005 gCm^{-3}h^{-1}. The research findings indicate that the Kiri Reservior demonstrates characteristics of high to moderate productivity, substantiated by a substantial organic material synthesis rate.

Keywords: Primary Productivity, Kiri Reservoir, community respiration, Adamawa.,

INTRODUCTION
Primary productivity is a desirable factor for the environmental health status of surface waters like reservoirs, rivers, lakes, estuaries, and oceans (Mir *et al*., 2015). This productivity is critically important in ensuring the optimum environmental quality of any aquatic environment and, as such, is a major factor in obtaining good productivity and ultimately high fish yields (Owato *et al*., 2016).

Primary productivity is the activity of chlorophyll plants in producing organic matter in a process known as photosynthesis. The value of primary productivity can be said to be the intensity of light and nutrients (Purina *et al*., 2018). The trophic status of any water is always affected by the presence of nutrients. The trophic status represents the total concentration of phosphorus (essential substances for algae growth), the concentration of chlorophyll-a, and

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the visibility of waters. The distribution of light and nutrients in the waters is generally not compatible with the needs of phytoplankton (Alianto *et al*., 2008). The health of water in reservoirs, rivers, and other water bodies is judged by its chemical, physical, and biological makeup. Sadly, bad waste management has caused serious pollution, making less freshwater available for productive use. Studies have shown that the deterioration of water quality and low faunal abundance and diversity are caused by stress imposed by effluents from land-based sources (Kansas Department of Health and Environment [KDHE], (2001). Continuous and rigorous scientific inquiry is essential to comprehensively understand the complex processes inherent in water systems. This research aims to determine the primary productivity of Kiri Reservior.

MATERIALS AND METHODS

Description of the Study Site

Kiri Reservoir emerges from the lower Gongola River Basin's floodplain, located 25 kilometers before the river meets Benue at Numan. Geological research indicates its formation resulted from lithospheric thinning, generating elongated depressions that accumulated diverse sedimentary environments (Whiteman 1982). Kiri Reservoir is strategically positioned in Shelleng Local Government Area, Adamawa State, specifically located at 9°42' North latitude and 12°01' East longitude. The region is characterized by a sedimentary geological landscape, comprising complex rock formations including shale, interspersed limestone bands, and lignite deposits. Extensive alluvial deposits cover the area, particularly along the expansive channels of Rivers Benue and Gongola, which overlay Cretaceous geological strata. The topography is predominantly low-lying, with elevations ranging between 500 and 700 meters above sea level. The area's topographical features are defined by widespread floodplains and interconnected alluvial swamps. Numerous locations are inherently vulnerable to flooding, water logging, and swamp development along river drainage systems. The unique geological composition of subsoil and shale formations enables substantial subsurface water transmission, creating dynamic water table conditions characterized by significant seasonal variations (Zemba, and Adebayo 2016).

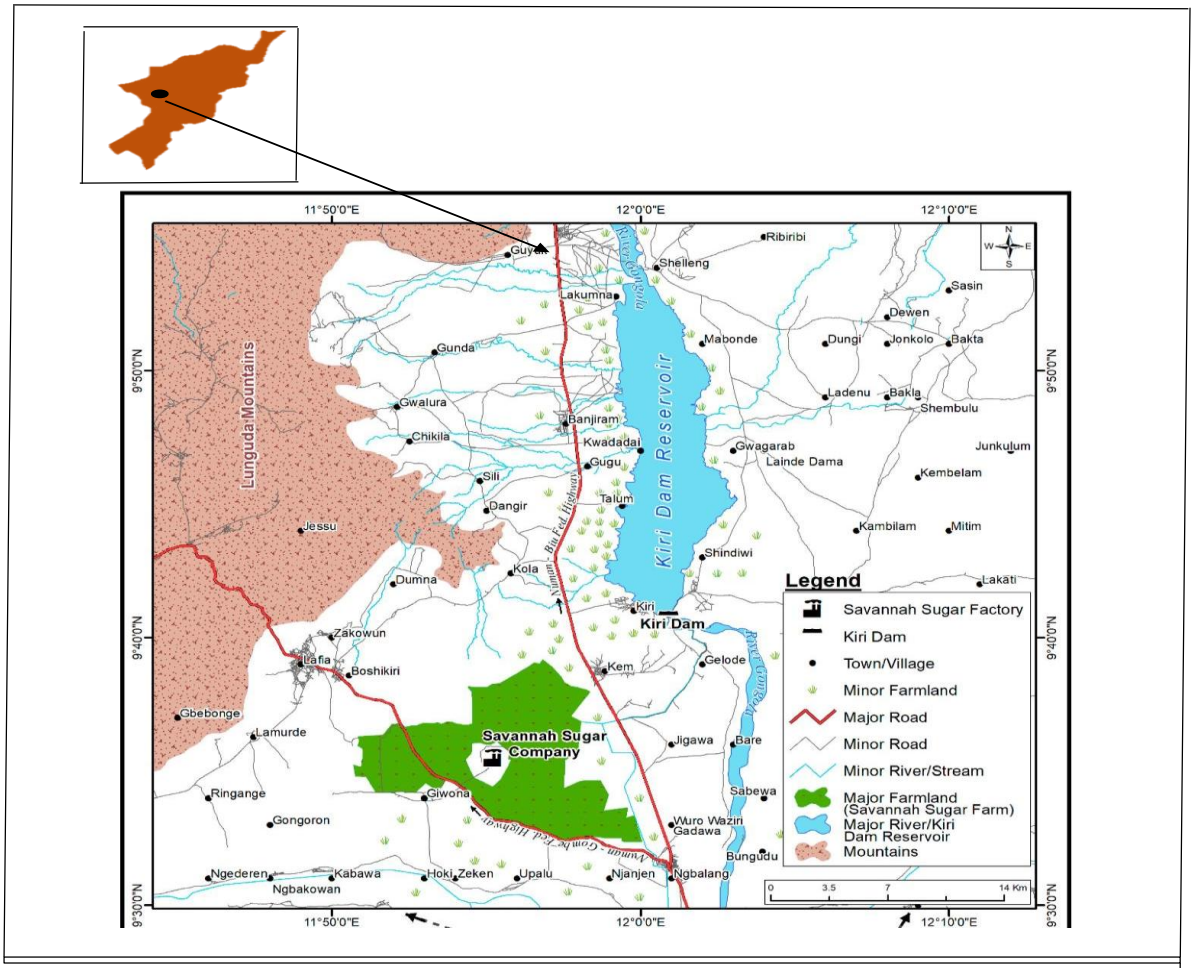

Figure 1: Map of Adamawa State, showing Kiri Reservoir (Adapted from Taitiya *et al*., 2020)

Sample Collection

Water samples were collected for the period of five months (October 2023, to February 2024), and triplicate samples were collected during the morning hours (8:00–10:00 AM) from four designated sampling stations, following the research design at the study site. The samples were preserved in the field by adding three drops of concentrated sulfuric acid and transported to the laboratory in a cool box to maintain nitrogen balance for further analysis.

Primary Productivity

The Primary productivity was measured using the light and dark bottle method. The water samples were collected from four different sampling stations of the dam from October 2023 to February 2024. The light and dark bottle method was used to study primary productivity. Water samples were collected in three bottles: one dark bottle and two light bottles. The first light bottle was used to measure the initial dissolved oxygen level using Winkler's method (APHA, 2018). The other two bottles, one light and one dark were submerged vertically underwater for six hours to incubate. After the incubation, the bottles were removed, and the dissolved oxygen concentration was immediately preserved using 4% neutral formalin (APHA, 2018).

Primary productivity is expressed in terms listed below

i. Gross Oxygen Production (GOP) mg L^{-1} = LB-DB/h
ii. Net Oxygen Production (NOP) mg L^{-1} = LB-IB/h
iii. Community Respiration (CR) mg L^{-1} = IB-DB/h

The values of gross and net primary productivity were calculated as follows

i. Gross Primary Productivity (GPP) g C m^{-3} h^{-1} = GOP/1.2 x 0.375 x h
ii. Net Primary Productivity (NPP) g C m^{-3} h^{-1} = NOP/1.2 x 0.375 x h
iii. Community Respiration (CR) g C m^{-3} h^{-1} = GPP- NPP

Where,
LB = Dissolved oxygen level in light bottle
DB = Dissolved oxygen level in a dark bottle
IB = Dissolved oxygen level in the initial bottle
h = Duration of incubation or exposure
1.2 = A constant (the photosynthetic quotient for the phytoplankton)
0.375 = A factor value (1 g of oxygen is equal to 0.375 g carbon)
Wrinkler's volumetric method (APHA, 2018).

Data Analysis

The data obtained were organized using Microsoft Excel (Version 2010). Phytoplankton analysis was performed using the PAST Statistical Package (Version 2.10) to calculate rankings based on the Shannon-Weiner Diversity Index (Orfanidis *et al*., 2007).

RESULTS AND DISCUSSION

In the present investigation, the monthly Gross Primary Productivity (GPP) distribution showed that the highest is 0.126±0.02 $gCm^{-3}h^{-1}$ followed by 0.110±0.005 $gCm^{-3}h^{-1}$ in January 2024, 0.108±0.006 $gCm^{-3}h^{-1}$, and 0.108±0.005 $gCm^{-3}h^{-1}$ in February 2024 and November 2023 respectively, the least was recorded in December 2023 0.106±0.004 $gCm^{-3}h^{-1}$. The highest Net Primary Productivity (NPP) is 0.067±0.004 $gCm^{-3}h^{-1}$, followed by 0.065±0.002 $gCm^{-3}h^{-1}$ in December 2023. While 0.064±0.001 $gCm^{-3}h^{-1}$ was recorded in November 2023, 0.063±0.003 $gCm^{-3}h^{-1}$ in January 2024, February 2024 had the least 0.059±0.005 $gCm^{-3}h^{-1}$. The Community Respiration (CR) showed that the highest was recorded in both January 2024 and November 2023 with 0.047±0.005 $gCm^{-3}h^{-1}$ and 0.047±0.004 $gCm^{-3}h^{-1}$ respectively, followed by 0.045±0.003 $gCm^{-3}h^{-1}$ in October 2023 and 0.044±0.004 $gCm^{-3}h^{-1}$ in December 2023, the least 0.043±0.003 $gCm^{-3}h^{-1}$ was recorded in February 2024 (Table 1).

The Gross Primary Productivity (GPP) distribution about the various sites, showed that the highest of 0.119 $gCm^{-3}h^{-1}$ was recorded in Site A, followed by 0.116 $gCm^{-3}h^{-1}$ in the second and the third sites respectively and 0.106 $gCm^{-3}h^{-1}$ was recorded in the last site as the least. The highest Net Primary Productivity (NPP) 0.064 $gCm^{-3}h^{-1}$ was recorded in Site A, followed by 0.065 $gCm^{-3}h^{-1}$ in Site B. While 0.063 $gCm^{-3}h^{-1}$ was recorded in Site C, the least 0.061 $gCm^{-3}h^{-1}$ was recorded in Site D. The Community Respiration (CR) showed that the highest 0.051 $gCm^{-3}h^{-1}$ was recorded in Site A, followed by 0.047 in Site B, 0.043 $gCm^{-3}h^{-1}$ in Site D, the least 0.042 $gCm^{-3}h^{-1}$ was recorded in Site C (Table 2)

Table 1: Monthly Variation of Primary Productivity of Kiri Reservoir, Adamawa State (October 2023 to February 2024).

Parameter	October	November	December	January	February
Gross primary productivity ($gCm^{-3}h^{-1}$)	0.126±0.02	0.108±0.005	0.106±0.004	0.110±0.005	0.108±0.006
Net primary productivity ($gCm^{-3}h^{-1}$)	0.067±0.004	0.064±0.001	0.065±0.002	0.063±0.003	0.059±0.005
Community respiration ($gCm^{-3}h^{-1}$)	0.045±0.003	0.047±0.004	0.044±0.004	0.047±0.005	0.043±0.003

F=284.11, df=2,4, P=0.00

Table 2: Mean Value of Primary Productivity at four sites of Kiri Reservoir, Adamawa State (October 2023 to February 2024).

Parameter	Site A	Site B	Site C	Site D
Gross primary productivity ($gCm^{-3}h^{-1}$)	0.119	0.111	0.111	0.106
Net primary productivity ($gCm^{-3}h^{-1}$)	0.064	0.065	0.063	0.061
Community respiration ($gCm^{-3}h^{-1}$)	0.051	0.047	0.042	0.043

F=287.77, df=2,9, P=0.00

DISCUSSION

Weather conditions play a crucial role in influencing the productivity of aquatic ecosystems. The Gross Primary Production (GPP) recorded in the present study falls below what Antaryami and Sunil (2014) recorded when they reported that the monthly value of GPP ranged between 0.42 $gC/m^3/d$ and 2.02 $gC/m^3/d$, during the first year and in between 0.59 $gC/m^3/d$ and 2.53 $gC/m^3/d$ during the second year of investigation, Retnoningtyas (2013), stated that the value of the primary productivity of the Thousand Islands ranged from 46.88 to 39.06 $gCm^{-3}h^{-1}$/hour. Alianto *et al*. (2008) conducted a study on primary productivity in Banten Bay and reported a value of 14.15 to 29.59 $gCm^{-3}h^{-1}$. These reports are higher than the report of the present study. The low productivity in the present study could be due to the season; winter could be attributed to the reduced photoperiod coupled with low light intensity, temperature, and scarce phytoplankton (Chinnaiah and Madhu, 2010). As such, high phytoplankton density and algal blooms are influenced by sunshine with high temperatures (Antaryami and Sunil, 2014). These studies revealed distinct seasonal and bimodal patterns of variation in the GPP value, having winter and summer peaks (Singh, 1993; Hari and Aziz, 2000; Kumar and Singh, 2006). A higher value of respiration as a percent of gross production was possible because of the high microbial population (Sinha and Choudhary, 2009).

The Net Primary Production (NPP) of phytoplankton in the present study varied from what was recorded by Antaryami and Sunil (2014), where they reported 0.08 $gC/m^3/d$ to 0.84 $gC/m^3/d$ and from 0.17 $gC/m^3/d$ to 1.69 $gC/m^3/d$ during the first and second year of investigations respectively. Mishra (2017) reported an NPP between 0.20 to 0.27$gC\ m^{-3}h^{-1}$ with an average value of 0.24 $gC\ m^{-3}h^{-1}$. Rajkumar (2005) found an average NPP of 0.31$gC\ m^{-3}h^{-1}$ in the surface waters of Daya Reservoir, India. NPP value showed the same seasonal and bimodal pattern of variations as shown by GPP values. The NPP had a direct relationship with the temperature in the present study. Similar findings were made by Kumar and Choudhary (2007). The ratio of net and gross primary production is essential for the evaluation of the amount of gross production available to consumers (Singh and Singh, 2014). This statement holds good as the higher values of net, gross primary productions were reported in November when weather conditions were bright and clear and this allowed for better penetration of light into the water body thereby facilitating the higher rate of planktonic photosynthesis and thus ultimately the productivity of the freshwater ecosystem (Madhupratap, 2016).

The Community Respiration (CR) of phytoplankton was lower than the report of Antaryami and Sunil (2014), who had CR ranged between 0.17 $gC/m^3/d$ and 1.18 $gC/m^3/d$ during the first and second year of investigation. So, this investigation reveals that the lake is eutrophic. The decreased values of CR recorded during harmattan in the present study may have resulted from low water temperature and reduced light (Ahmed *et al*., 2005, Dash *et al*., 2011 Singh, 2014). There was a direct correlation between temperature and productivity, which is in agreement with Mohanty *et al*., (2000), Wetzel (2010), Hall and Moll (2014), Srinivasan (2015), and Thomas *et al*., (2019).

CONCLUSION

Based on the results and observations of this research, the productivity of Kiri Dam can be categorized as high to moderate due to the significant rate of organic material synthesis. Therefore, this water body can be classified as falling between "eutrophic," "oligotrophic," and "mesotrophic" conditions and therefore the research should be carried out throughout the year to compare the variations due to seasonal differences.

REFERENCES

Adakole, J. A. (2015). The effects of domestic, agricultural, and industrial effluents on the water quality and biota of Bindere streams, Zaria- Nigeria, PhD Thesis, Department of Biological Sciences, A.B.U. Zaria, Nigeria, Pp 256.

Adebayo, A. A. and Tukur, L. B. (1999). Adamawa State in Maps.Yola: Paraclete Publishers, Adamawa State, Nigeria Pp.19-28.

Alianto, Adiwilaga, E. M. and Damar, A. (2008). *Jurnal Ilmu-Ilmu Perairan Dan Perikanan Indonesia* **15(5)**:21 - 26.

Antaryami, K.A. and Sunil, K.C. (2014). Assessment of Primary Productivity of Phytoplankton of Gogabil Lake Wetland, Katihar, Bihar, India, *Poll Res.* 33 (2): 465-467

American Public Health Association [APHA] (2018). Standard methods for the examination of water and wastewater. 26th edition, Washington, D. C. Pp.126.

Dash S, Patra A.K. and Adhikary S., (2011). Primary Productivity of Kharasrota River (India). *Journal Economic physiology*. 11: 219-225.

Gotelli, N. J. and Chao, A. (2013). Measuring and Estimating Species Richness, Species Diversity, and Biotic Similarity from Sampling Data. *Encyclopedia of Biodiversity*, **5**:195-211.

Hal, C., and Moll. R, (2014). Methods of assessing aquatic primary production in Primary production of the Biosphere (eds. H. Lieth and R. Whittaker). *Springer Verlag,* New York, Pp 19-53.

Heip, C.H.R., Herman, P.M.J., and Soetaert, K. (2018). Indices of Diversity and Evenness. *Oceanis*, 24(4):6–87.

Kansas Department of Health and Environment, Division of Environment [KDHE] (2001). *Data for the Lower Big Blue Subbasin*, **3(4)**: 21-30.

Madhupratap, M., M. Gauns, N. Ramaiah, S. Prasanna Kumar, P.M. Muraleedharan, S. N. De Souza, S. Sardesai and Usha Muraleedharan, (2016). Biogeochemistry of the Bay of Bengal: Physical, Chemical, and primary productivity characteristics of the central and western Bay of Bengal during summer monsoon, Pp 43-52.

Mir, A. Q., Pandey, G. C. and Sarwar, S. G. (2015). Impact of skim effluent on the water quality of Anchar Lake, Kashmir. In: Fundamentals of Limnology. S.B. Nangia for APH Publishing Corporation 5, Ansari Road, Darya Ganj. New Delhi, Pp 44-49.

Mohanty, S. S., Pramanik D. S. and Dash B. P. (2014). Primary Productivity of Bay of Bengal at Chandipur in Odisha, India. *International Journal of Scientific and Research Publications*, 4**(10),**1-6.

Mohanty, R. K. (2000). Primary production and seasonal plankton abundance in artificially controlled semi-intensive shrimp pond. *Journal of Indian Coastal Agriculture Resources*, 18:40–46.

Morris, E. K., Caruso, T., Buscot, F., Fischer, M., Hancock, C., Maier, T. S., Meiners, T., M€uller, C., Obermaier, E, Prati, D., Socher, S.A., Sonnemann, I. and W€aschke, N.O. Trophic status evaluation for 154 lakes in Quebec, Canada: monitoring and recommendations. *Water Quality Research Journal*, **42(4)**:252-268.

Orfanidis, S. J., Sunday, P., and Klevin, C. C. A. (2007). Rutgers University Electrical and Computer Engineering Department, Optimum Signal Processing. Pp 1-77.

Ortiz-Burgos, S. (2016). Shannon-Weaver Diversity Index. In Encyclopedia of Estuaries Springer Netherlands. Pp. 572-573.

Owato, G. O., Olendi, R. and Steve, O. N. (2016). Assessment of primary productivity, nutrient levels, and trophic status. *International Journal of Fisheries Aquatic Studies*, **1(3)**:15-15.

Purina, I., Labucis, A., Barda, I., Jurgensone, I. and Aigars, J. (2018). *Oceanologia*, **60(15)**: 544–52.

Rajkumar, D. (2005). Some Aspects of Fish Biology and Fisheries Potential about Current Water Quality Status of Daya Reservoir, Udaipur, (Rajasthan) Ph.D. (Limnology) Thesis, Maharana Pratap University of Agriculture and Technology, Udaipur.

Ramade, F. (2005). Ecology elements. Applied ecology. 4th edition, Dunod, Paris, France, Pp 864.

Retnoningtyas, H. (2013). Study of microphytobenthos primary productivity in Pulau Lancang, Kepulauan Seribu [tesis]. Bogor (ID): Institut Pertanian Bogor. Pp 456.

Singh, A.K. and Singh D.K. (2014). A Comparative study of the Phytoplanktonic primary production of river Ganga and Pond of Patna (Bihar). *India Journal of Environment. Biology*,20:26 –270.

Sreenivasan, A. (2015). Primary production in three upland lakes of Madras state. *Current Science*, 32:130-131.

Thomas, P. A., Abraham. T. and Abraham K. G., (2019). Observation on the primary productivity of Sasthamkotta Lake: Dn. Alexender. *Environment Biology of Trivandrum,* Pp 1 – 7.

Zemba, A. A., and Bonifice, T. J. (2014). Effects of Kiri Dam Construction on the Economy of Lower Gongola Basin of Shelling Local Government, Adamawa State, Nigeria. *International Journal of Economic Development*, **5**(**1**): 48–54.