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ASSESSMENT OF PHYTOPLANKTON COMPOSITION AND ABUNDANCE OF THE UPPER NIGER RIVER BASIN RESERVOIR

*Ibrahim, S. U., Kolo, R. J., Peter, J. S. and Gana, A. B.
Department of Water Resources, Aquaculture and Fisheries Technology, Federal University of Technology, P. M. B. 65, Minna, Niger State Nigeria

Contacts: suibrahim@futminna.edu.ng +234 7039025846

ABSTRACT

The study evaluated the composition, abundance, and spatial distribution of phytoplankton in the Upper Niger River Basin Reservoir, Nigeria, to assess ecological status and anthropogenic impacts. Samples were collected monthly from February to July 2022 at four sites (landing site, vegetated area, open water and dam site) representing different environmental conditions. Phytoplankton were sampled using a 75 mm plankton net, preserved in 4% formalin and analyzed microscopically for identification and enumeration. Four major phytoplankton classes were identified: Bacillariophyceae, Euglenophyceae, Dinophyceae, and Chlorophyceae. Bacillariophyceae (diatoms) showed the highest diversity across all stations, with the genus *Nitzschia* dominating at the landing site, indicating eutrophic to hypereutrophic conditions linked to organic pollution. Data analysis revealed significant spatial variation ($p<0.05$) among phytoplankton groups. Euglenophyceae recorded the highest mean abundance at the landing site (151.50±2.12), further suggesting nutrient enrichment. The dominance of pollution tolerant and eutrophic indicator species, especially at the landing site, reflects substantial nutrient input from human activities. This indicates advanced eutrophication, which can threaten ecological integrity through oxygen depletion, biodiversity loss, and declining water quality. These findings provide baseline data essential for developing management strategies to control nutrient pollution and sustain the reservoir's ecological health. Therefore, based on these findings, it is recommended that a continuous phytoplankton water quality program be establish and also implement watershed nutrient control actions to reduced nitrogen and phosphorus loading.

Keywords: Phytoplankton, Eutrophication; Upper Niger River Basin Reservoir, Nutrient pollution; Anthropogenic activities.

Introduction

Assessing ecological quality is fundamental to the management and conservation of aquatic ecosystems (Tampo *et al.*, 2023). While chemical analyses provide temporary data, they often fail to capture long-term environmental stressors over time (Schuijt *et al.*, 2021). Consequently, biological assessment, particularly plankton, offers a more integrated approach since these organisms reflect cumulative environmental conditions. Among them, phytoplankton are especially valuable indicators due to their foundational position in the food web, Sensitivity to physicochemical changes and direct exposure to the water column (Celia *et al.*, 2021) Phytoplankton are also highly suitable for determining the impact of toxic substances on the environment (Gojkovic *et al.*, 2023).

Phytoplankton require light and nutrients for growth, through photosynthesis, they convert solar energy into chemical energy, driving nutrient cycling and supporting higher trophic levels, including zooplankton and fish. Their abundance and composition therefore determine the productivity and carrying capacity of aquatic systems. Thus, the abundance and composition of the phytoplankton community are fundamental determinants of an aquatic system's overall productivity and carrying capacity (Celia *et al.*, 2021).

However, environmental conditions such as nutrient enrichment and rising temperatures can trigger excessive phytoplankton growth, leading to blooms. These blooms increase water turbidity, reduce light penetration, and inhibit submerged vegetation. Upon decomposition, phytoplankton consume dissolved oxygen, causing hypoxic conditions that threaten aquatic life, including fish and benthic organisms. Nevertheless, the same factors that promote their growth can also lead to severe ecological imbalance (Brenckman *et al.*, 2025).

The Upper Niger River Basin Reservoir serves as a vital resource for local communities, supporting their livelihoods through various activities, including domestic use and agriculture (Liersch *et al.*, 2019). However, these anthropogenic activities have led to increased pollution in the reservoir (Gavrilaș *et al.*, 2025). This pollution can significantly impact the abundance and diversity of phytoplankton, which play a crucial ecological role as primary producers, fuelling food webs both directly and indirectly (Naselli-Flores and Padisák, 2023).

Advances in satellite technology has significantly transformed the mapping and monitoring of phytoplankton in aquatic environments. Traditionally, phytoplankton studies relied on labour-intensive field sampling, which was often limited in spatial and temporal coverage. However, allow scientists to observe large water bodies continuously, providing a synoptic view of phytoplankton distribution across aquatic environment, helping researchers understand bloom dynamics and ecological processes, which is crucial for monitoring water quality, Overall, phytoplankton serve as indispensable tools for evaluating aquatic health and guiding sustainable water resource management.

Materials and Methods

Description of the study area

The research was performed at the Upper Niger River Basin Reservoir, a significant water body in North Central Nigeria. The reservoir is located within the administrative boundaries of the Bosso Local Government Area of Niger State. Geographically, the sampling area lies at coordinates 9°40’40.4” N and 6°31’14.5” E. Field sampling for the determination of phytoplankton composition and abundance was carried out over a six-month duration, encompassing both dry and early rainy season conditions, from February 2022 to July 2022.

Experimental Materials

Field Sampling and Site Characterization

Phytoplankton samples were collected from the reservoir using a plankton net (75 mm) and transferred into pre-labelled plastic jar. The precise geographic coordinates of each sampling station were recorded using a handheld Global Positioning System (GPS) unit (Model: GPSMAP 76 garmin).

Sample collection, Preservation and Laboratory Processing

The samples were collected through a sweep made by moving the net within the water over 0.5 m and turns back and repeated same process back through the same distance vertically. Immediately after collection, samples were preserved in the field by adding 4% buffered formalin to prevent biotic degradation. In the laboratory, the preserved samples were concentrated for analysis. A fixed volume of each sample was centrifuged using a benchtop centrifuge (Model: 800).

Phytoplankton Identification and Enumeration

Following concentration, a subsample of a known volume was transferred using a calibrated pipette onto a counting chamber. Phytoplankton were identified to the lowest feasible taxonomic level and counted using a high-power compound microscope (Olympus: Model), equipped with a digital camera for imaging. Taxonomic identification was confirmed using standard authoritative monographs and regional algal flora guides.

Geospatial Analysis

A satellite image of the Upper Niger River Basin Reservoir and its catchment was acquired. The imagery was used for mapping sampling locations, assessing land use and analysing surface water characteristics.

Data Collection

The data was obtained by field survey, satellite images, GIS software, Microsoft word and Microsoft excel (Figure 1), and four sites (Figure 2) were selected based on the activities conducted on the reservoir (Table 1).

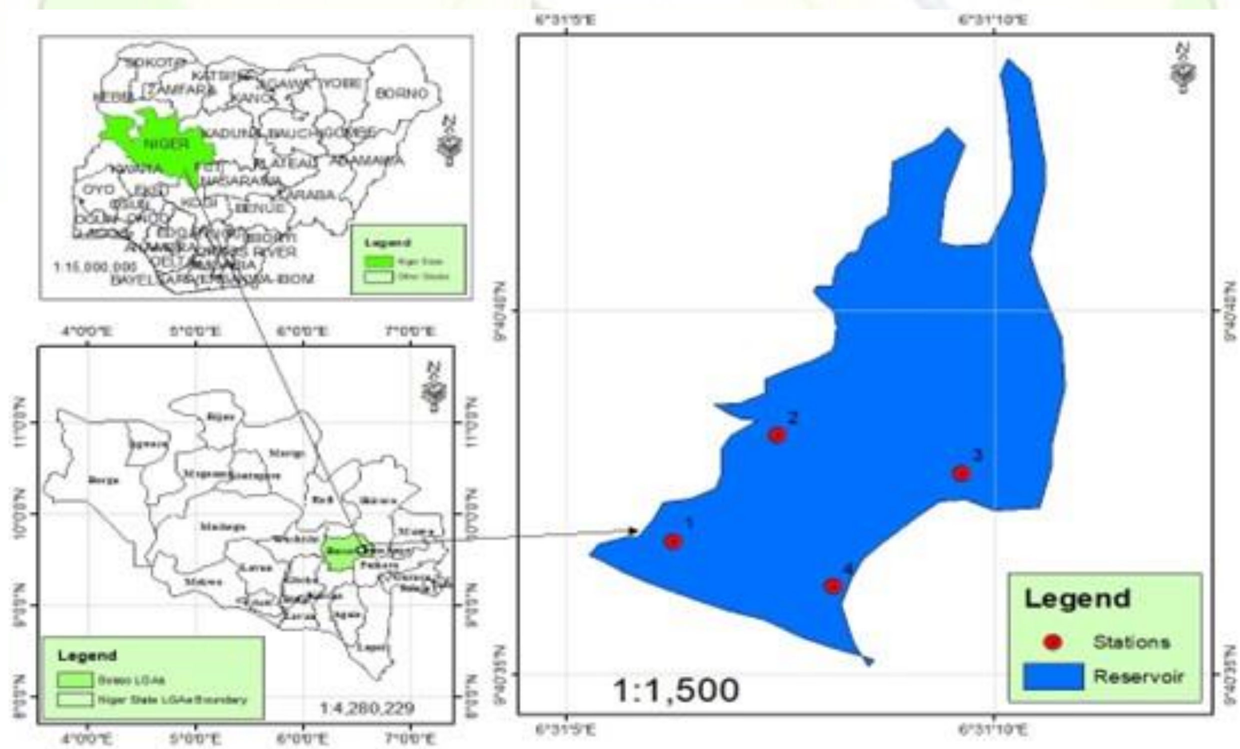

Figure 1: Nigeria Map indicating Niger State and the Study Area

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Figure 2a: Quick bird Image of the Reservoir Indicating Sampling Stations

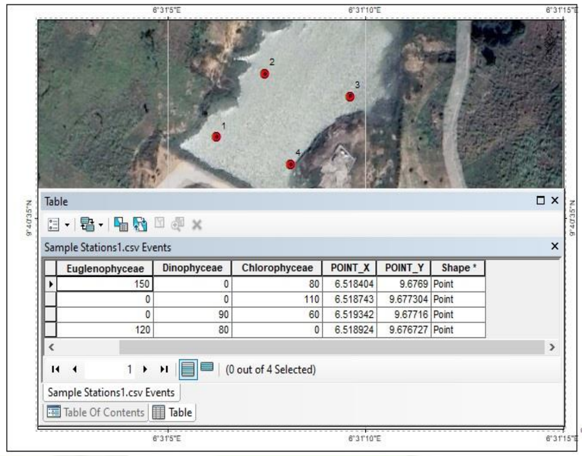

Figure 2b: Database map of study area

Table 1: Attribute of the Selected Sampling Site

Sampling	Location	Description
Station 1	Landing site	First point of contact
Station 2	Site close to vegetation	This is the site close to vegetation cover
Station 3	Open water	Site close to the middle of water
Station 4	Dam site	The site close to dam

Data Analysis

Data were analysed using one-way analysis of variance (ANOVA) using Minitab, version 14.0. Differences between treatments were compared using Tukey's multiple comparison test. The level of significance was set at $p<0.05$.

Results and Discussions

The phytoplankton species identified across the stations in Upper Niger Reservoir (Table 2) offers a qualitative snapshot of the phytoplankton community structure at four distinct stations. Phytoplankton, as primary producers, form the base of most aquatic food webs and are highly sensitive to changes in their environment (Jahan and Singh, 2023). Four different families of phytoplankton were identified in this study. Similarly, Etim (2019) identified 5 taxonomic families (Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae and Chrysophyceae) in the lower Cross River system, Nigeria. However, this does not corroborate with the results reported by Moruff *et al.* (2016). Theses variations could be attributed to different location and environment. Consequently, the composition, abundance, and distribution of phytoplankton serve as excellent biological indicators for assessing the ecological status and water quality of aquatic ecosystems like reservoirs (Essa *et al.*, 2024).

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Table 2: Phytoplankton Species Identified Across the Stations in Upper Niger Reservoir

	STATION 1	STATION 2	STATION 3	STATION 4
Bacillariophyceae				
Melosira spp	++	__	+	+
Nitzschia spp	+++	++	++	__
Navicula spp	+	__	__	+
Peridinium spp	__	+	++	__
Thalassirora spp	__	++	__	++
Odontella spp	__	+	++	__
Leptocyclindrus spp	+	+	__	+
Rhizosolentia spp	++	__	__	+
Euglenophyceaea				
Prorocentrum spp	++	__	__	++
Dinophyceae				
Gymnodium spp	__	__	++	+
Chlorophycea				
Pediastrum spp	__	+	__	__
Spirogyra spp	++	__	+	__

__ = absent, + = sparse, ++ = abundant and +++ = dominant.

The dominance of Bacillariophyceae (Diatoms) in this study, the most striking feature of the dataset is the pronounced diversity and its abundance. Flori *et al.* (2025) reported that diatoms are ubiquitous in freshwater environments, and their dominance often points to specific environmental conditions, which they require silica for the formation of their frustules. Therefore, their abundance suggests that dissolved silica is not a limiting nutrient in this system. Also, the presence of both centric (*Melosira*, *Thalassiosira*) and pennate (*Nitzschia*, *Navicula*) diatoms indicates a varied habitat structure within the reservoir. This genus (*Nitzschia)* is dominant (+++) at Station 1 and abundant (++) at Stations 2 and 3. However, many species within the genus *Nitzschia* are known to be tolerant of high levels of organic

pollution and nutrient enrichment, particularly nitrogen (Trobajo *et al.*, 2004). Their dominance is a classic indicator of eutrophic to hypereutrophic conditions (Trobajo *et al.*, 2009). The prevalence of *Nitzschia* across the first three stations, especially its dominance at Station 1, strongly suggests significant nutrient loading in these parts of the reservoir. These motile dinoflagellates (*Peridinium* and *Gymnodinium)* are abundant at Station 3. Hall and Paerl (2011) observed that dinoflagellates can perform vertical migrations in the water column, allowing them to access nutrients in deeper waters and light at the surface, giving them a competitive advantage in stratified or stable water columns. Therefore, their abundance at Station 3 suggests nutrient rich conditions, possibly with more water column stability compared to Station 1.

This study further revealed (Table 3 and Figure1) the quantitative data on the distribution of four major phytoplankton classes (Bacillariophyceae, Euglenophyceae, Dinophyceae, and Chlorophyceae), across four sampling stations in the Upper Niger Reservoir. This highlights significant spatial variations in the phytoplankton community structure, which are powerful indicators of differing environmental conditions, particularly water quality and hydrology (Zhang *et al.*, 2021).

Table 3: Station Variation of Phytoplankton Distribution

SPECIES	STATION 1	STATION 2	STATION 3	STATION 4
Bacillariophyceae	71.25 ± 63.56^{a}	51.25 ± 43.48^{a}	47.50 ± 51.47^{a}	47.75 ± 41.06^{a}
Euglenophyceaea	151.50 ± 2.12^{a}	0.00 ± 0.00^{c}	0.00 ± 0.00^{c}	121.50 ± 2.12^{b}
Dinophyceae	0.00 ± 0.00^{c}	0.00 ± 0.00^{c}	92.50 ± 3.53^{a}	81.00 ± 1.41^{b}
Chlorophycea	40.00 ± 56.56^{a}	55.00 ± 77.78^{a}	30.00 ± 42.42^{a}	0.00 ± 0.00^{b}
Chlorophycea	40.00 ± 56.56^{a}	55.00 ± 77.78^{a}	30.00 ± 42.42^{a}	0.00 ± 0.00^{b}

Values on the same row with different superscripts are significantly different ($p<0.05$)

Figure 3a: Shonghai reservoir indicating the distribution of *Baccillariophyceae*

Figure 3b: Shonghai reservoir indicating the distribution of *Euglenophyceae*

Figure 3c: Shonghai reservoir indicating the distribution of *Dinophyceae*

Figure 3d: Shonghai reservoir indicating the distribution of *Chlorophycea*

Figure 3: Shonghai Reservoir Showing the Distribution of Phytoplankton

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In station 1, *Euglenophyceaea* recorded the highest mean values and differ significantly (p<0.05) from other stations. This high variability suggests that the distribution of these phytoplankton is highly heterogeneous within the stations. Such heterogeneous is a fundamental characteristic of plankton ecology and can be caused by micro-scale nutrient hotspots, physical aggregation, and boom-and-bust dynamics (Tang *et al.*, 2024). The mean abundance of *Bacillariophyceae* ranges from 47.50 to 71.25 across the stations. Statistically, there is no significant difference (p<0.05) in their abundance among the four stations. This result suggests that *Bacillariophyceae* form a ubiquitous and relatively stable component of the phytoplankton community throughout the sampled areas of the reservoir. The factors controlling their overall abundance, such as the availability of dissolved silica and general light conditions, appear to be relatively uniform across these stations.

Conclusion

The qualitative analysis of the phytoplankton community in the Upper Niger Reservoir indicates a significant gradient of water quality across the four stations. The assemblage at Station 1 strongly suggests hypereutrophic conditions, likely driven by high inputs of organic and inorganic nutrients. Stations 2 and 3 also show clear signs of eutrophication, though the community composition differs, pointing to spatial variations in environmental drivers. Station 4 appears to be comparatively less impacted. The dominance of eutrophic indicator species is a cause for concern, as advanced eutrophication can lead to oxygen depletion, loss of biodiversity, fish deaths, and a general degradation of water quality, impacting its use for drinking, fishing, and recreation. Hence, this information is crucial for targeted management strategies aimed at mitigating nutrient pollution and preserving the ecological health of the reservoir.

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