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Phytoplankton diversity and their relationship with water quality parameters in the middle basin of Ogun River, Abeokuta, Southwest Nigeria

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SUMMARY

Phytoplankton are crucial bioindicators for assessing freshwater ecosystem health. This study investigates the diversity and distribution of phytoplankton and key water quality parameters in the Ogun River. Monthly samples were collected from three sites along the river between February and August 2024. Phytoplankton samples were preserved with 4% formalin and analyzed microscopically, while water quality parameters, including temperature, pH, dissolved oxygen, conductivity, transparency, total dissolved solids, nitrate, phosphate, alkalinity, and hardness, were measured using standard methods. Results showed temperature ranged from 27.3–31.9 °C, pH from 6.7–9.4, dissolved oxygen from 4.3–7.2 mgL^{-1}, conductivity from 10.8–20.9 µS/cm, transparency from 0.27–1 m, and other parameters within specified ranges. Sixteen phytoplankton species from 10 families were identified, with the Bacillariophyceae family being the most dominant, representing 7 species. Lyngbya spp. was the most abundant species, followed by Pediastrum simplex. Species richness was 12 species at Site A, 13 at Site B, and 14 at Site C. Dominance values were 0.13, 0.11, and 0.12, respectively. Simpson's diversity index ranged from 0.87 to 0.89, and the Shannon-Weiner index was 2.24 at Site A, 2.38 at Site B, and 2.35 at Site C. One-way ANOVA tests showed no statistically significant differences in diversity indices among the three sampling sites ($p > 0.05$), indicating relatively consistent phytoplankton diversity across the study area. These findings highlight the importance of integrated biological and physicochemical monitoring for effective water management and ecosystem conservation in the Ogun River.

Keywords: *Phytoplankton; bio-indicator; species richness; water quality parameters; diversity index; water management*

INTRODUCTION

Phytoplankton are microscopic organisms that are not visible to the naked eye. They form a community of free-floating algae that play a crucial role in influencing the productivity of aquatic ecosystems (Joseph, 2017). As effective bio-indicators, phytoplankton are commonly used to assess the health of freshwater ecosystems (Ajagbe et al., 2019). These organisms form the base of the food chain in aquatic environments, supporting the survival of various fauna, including fish populations. Additionally, phytoplankton contributes nearly 70% of the world's atmospheric oxygen (Sekerci & Petrovskii, 2015) They exhibit significant diversity as aquatic organisms, and their growth, existence, and productivity are influenced by various biotic factors which include plant and animal activities, and abiotic factors such as temperature, solar radiation, and water conditions like phosphate and nitrate levels (Ajagbe et al., 2019). Phytoplankton are at the base of the food chain since they are susceptible to other aquatic predators like zooplankton. They are a diverse community that hails from different ancestral orders, which influences their variation in size, shape, color, type of metabolism, and the traits in which the environment also participates (Gabor et al., 2020).

The study of phytoplankton is considered very useful in the assessment of water quality and also how well-understood standing freshwater systems are. Standing freshwater systems are referred to as standing water, which has little or no motion (Pawar et al., 2006). According to Pawar et al. (2006), phytoplankton comprises thousands of microalgae species, including those from *Bacillariophyta* (diatoms), *Chlorophyta* (green algae), *Euglenophyta* (pigmented flagellates or phytoflagellates), and *Cyanophyta* (blue-green algae), among others. Phytoplankton are highly responsive to environmental changes, making them valuable indicators for assessing the ecological health of water bodies (Singh et al., 2013). However, it is important to note that excessive phytoplankton growth can lead to problems such as fish toxicity and the deterioration of water quality, posing challenges for effective water management. It is therefore necessary to study the factors that can control phytoplankton growth (Avik & Ruma, 2014).

Phytoplankton are distributed across various water depths, with their size influencing their spatial distribution. These photosynthetic microorganisms are adapted to survive in both open and partially enclosed water environments (Reynolds, 2006). Phytoplankton exhibits a wide range of sizes, from smaller than 2 µm to more than 200 µm. While most are microscopic and can only be observed under a light microscope, certain larger species, such as the spherical colonies of blue-green algae like Microcystis, are visible to the naked eye (Bellinger & Sigee, 2010). As the foundation of the aquatic food web, phytoplankton provides essential energy to other aquatic organisms. This energy is indirectly transferred to terrestrial life forms that rely on aquatic resources for their survival (Ajagbe et al., 2019). Phytoplankton also contributes to fish production. Moreover, some species have direct benefits for humans. Some phytoplankton, like Spirulina, are highly regarded for their cosmetic and

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medicinal benefits, while others are used as food or dietary supplements (Udayan et al., 2017). Spirulina, for example, has been cultivated by the Aztecs in Mexico and communities around Lake Chad as a source of nutrition. It is often processed into tablets and sold in health food stores as a popular supplement. (Bellinger & Sigee, 2010). According to Bakaeva et al. (2021), the distribution, abundance, species diversity, and composition of the phytoplankton are used to assess the biological integrity of a water body. The abundance of phytoplankton and taxa richness in floodplain lakes is influenced by hydrological conditions and water quality parameters (Grabowska et al., 2014). Many other studies also show the relationship between phytoplankton and water quality parameters (Sharma et al., 2020; Agarin et al., 2020; Umeoka, 2024).

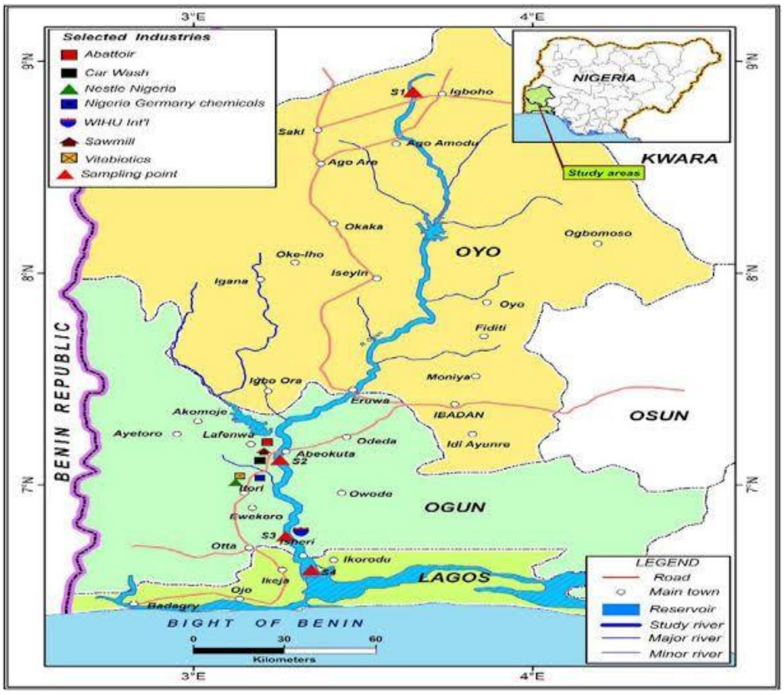
There seems to be a limited understanding of how water quality parameters specifically influence phytoplankton species composition in river systems, particularly in the middle basin of River Ogun, Abeokuta, Southwest Nigeria. While phytoplankton is widely recognized as a bio-indicator of aquatic health, studies focusing on the interaction between various water quality parameters (such as temperature, nutrient levels, and pH) and phytoplankton diversity in this region remain scarce. Most existing research on phytoplankton is generalized and may not adequately address the unique environmental factors affecting the River Ogun's ecosystem. This study aims to fill this gap by determining the species composition of phytoplankton in the middle basin of the River Ogun and exploring the influence of key water quality parameters on their distribution and diversity. This will provide valuable insights into the ecological health of the river, which can inform future conservation and water quality management strategies in the region.

MATERIALS AND METHODS

Study Area

The study area is the Ogun River catchment in southwestern Nigeria, located between latitudes 6°33' N and 8°58' N, and longitudes 2°40' E and 4°10' E (*Figure 1*). The catchment spans parts of Lagos and Ogun states, covering an area of approximately 23,000 km². The Ogun River originates from the Igaran hills at an elevation of about 530 meters above sea level and flows southward for approximately 480 km before emptying into the Lagos Lagoon. The river is dammed, and its major tributaries include the Ofiki and Opeki rivers. Around 9 km upstream from Abeokuta, the land gradient sharply changes, altering the river's flow from fast-moving to slow-moving. This change in morphology leads to the formation of alluvial deposits, which overlay the sedimentary formations of Coastal Plain Sands, Ilaro, and Ewekoro, extending toward the Lagos Lagoon.

Figure 1. **Map showing the Ogun River**



Collection of Water Samples

Before the collection of water samples, all polyethylene bottles were disinfected using a standard laboratory procedure. Each bottle was thoroughly washed with detergent and rinsed with tap water, followed by soaking in a 10% hydrochloric acid (HCl) solution for at least 20 minutes. After acid treatment, the bottles were rinsed three times with deionized water to

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remove any residual acid and allowed to air dry. This procedure ensured that all sampling containers were free from contaminants before use. At each site and on each sampling occasion, three replicate surface water samples were collected using separate, pre-cleaned 1L polyethylene bottles from February 2024 to July 2024. All collected water samples were transported to the laboratory for further analysis.

Measurement of Water Quality Parameters

Water temperature, transparency, pH, electrical conductivity, and total dissolved solids were the water quality parameters that were assessed in situ for each sample. Dissolved oxygen, nitrate, phosphate, alkalinity, and total hardness were examined monthly for six months in the wet laboratory of the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.

Determination of Water Temperature (°C)

The temperature of the water sample was determined by using a pH-EC-TDS meter (HANNA HI 9810), a multipurpose meter. The meter was dipped in the water sample collected in a beaker, and the result was digitally displayed on the instrument and recorded when the reading was steady.

Determination of Dissolved Oxygen (DO)

Using a 250ml stoppered glass bottle, water was carefully taken to the landing site to prevent air bubbles. The conventional Winkler method was employed to determine the dissolved oxygen in the water. Special care was taken to prevent any air from entering the bottle. First, 5 drops of Manganous Sulphate and 5 drops of Alkali-azide reagent were added to the water sample. Water was then added to fill the bottle, which was tightly sealed to prevent air bubbles and ensure no spillage. The bottle was gently inverted several times until the sample turned orange-yellow, and a flocculent precipitate formed, signifying the presence of dissolved oxygen. The precipitate was left to settle, clearing the upper half of the bottle. Finally, 10 drops of concentrated sulfuric acid were added, and the bottle was sealed again. It was inverted repeatedly until the precipitate dissolved completely, resulting in a clear, lipid-like solution. 5 ml of the solution was put in a calibrated plastic vessel, and a drop of starch solution was added to the water sample as an indicator; then the color changed to light blue. The water sample was continuously stirred while the titrant solution (sodium thiosulfate) was added to the calibrated plastic vessel until it became colorless, and the reading was taken.

Determination of Phosphate (mgL^{-1})

Phosphate was determined by putting 10 mL of the water sample in a plastic vessel that had been rinsed. Next, one packet of Hl 3833-0 phosphate reagent was added to the water and stirred until the solid dissolved. The solution turned blue. It was then transferred into a comparator, and after allowing it to stand for 1 minute, the color was matched with the solution in the cube. The results were recorded as the concentration of phosphate (PO_4^{3-}) in mgL^{-1} (ppm).

Determination of Nitrate (mgL^{-1})

A 10 ml water sample was placed in a rinsed glass cuvette. Next, one packet of HL 3874-0 nitrate reagent was added, and the mixture was stirred until the solid completely dissolved. The solution was then shaken vigorously for exactly 1 minute. After allowing the solution to develop color for 4 minutes, 5 mL of the treated sample was transferred into the comparator. The color of the solution was compared to that in the cube, and the result was multiplied by 4.43 to determine the nitrate concentration in mgL^{-1}.

Phytoplankton Collection and Identification

Phytoplankton samples were collected each month from February to August 2024, using a plankton net with a 25 cm diameter and a 50 µm mesh size, which is well-suited for capturing a broad range of microplankton. At every sampling site, the net was towed horizontally just below the water surface, at a consistent depth of about 0.5 meters. Each tow covered a distance of 100 meters, and the speed of the tow was kept steady at approximately 0.5 meters per second to ensure that the net moved smoothly through the water and collected an even sample of phytoplankton. To account for natural variability and improve the reliability of the results, three separate tows were performed at each site during every sampling event. After each tow, the net was rinsed from the outside to concentrate the collected organisms into the cod-end, and the resulting sample was transferred into a labeled 50 ml plastic bottle. All samples were preserved immediately with 4% formalin and transported to the laboratory for further microscopic analysis.

In the laboratory, each preserved sample was gently mixed and allowed to settle before carefully decanting the supernatant. Identification was carried out using a digital microscope at 400× magnification. While efforts were made to distinguish phytoplankton as precisely as possible, the limitations of light microscopy and the effects of formalin fixation meant that not all taxa could be reliably identified to species level. As a result, most phytoplankton were identified to the genus level, with species-level identification only attempted when distinctive morphological features were visible and matched descriptions in established taxonomic references, such as Bellinger & Sigee (2010) and Reynolds (2006). In cases where diagnostic features were masked or ambiguous, identification was conservatively limited to the genus. This approach ensured that the classification of phytoplankton reflected both the capabilities of the available equipment and the constraints of sample preservation, providing a transparent basis for interpreting community composition in the Ogun River.

RESULTS

Diversity of Phytoplankton in Ogun River

The distribution and diversity of phytoplankton in the Ogun River are presented in *Figure 2*. There were 16 species of phytoplankton belonging to 10 families in the samples collected from the river between February and

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July 2024. Of the sixteen taxa recorded, only *Pediastrum simplex* was identified to the species level; all other phytoplankton taxa were identified to the genus level based on available morphological features and reference descriptions (*Table 1*). *Table 2* shows the diversity indices of phytoplankton in each sampling site. The overall count of individual phytoplankton gathered from each sampling location was as follows: Site A (1012), Site B (828), Site C (1334), and the overall river total was 3174. The total species richness in the Ogun River was 16, with individual site richness as follows: Site A had 12 species, Site B had 13 species, and Site C had 14 species. Additional diversity components were also recorded for each site, along with their respective values. The dominance in sites A, B, and C was 0.13, 0.11, and 0.12, respectively. The Simpson index values for Sites A, B, and C were 0.87, 0.89, and 0.88, respectively. The Shannon-Weiner index also showed variation across the sites, with Site A (2.24), Site B (2.38), and Site C (2.35). The Evenness index was Site A (0.78), Site B (0.83), and Site C (0.75). A one-way ANOVA test was conducted to determine whether there were significant differences in phytoplankton diversity indices among the three sampling sites. The results (*Table 2*) showed that differences in species richness (Taxa_S), individual counts, dominance, Simpson diversity, Shannon diversity, and evenness were not statistically significant ($p > 0.05$). This suggests that phytoplankton diversity is relatively consistent across the sampled locations in the middle basin of the Ogun River.

Figure 2. **Phytoplankton diversity of the middle basin of Ogun River, Abeokuta, Southwest, Nigeria**

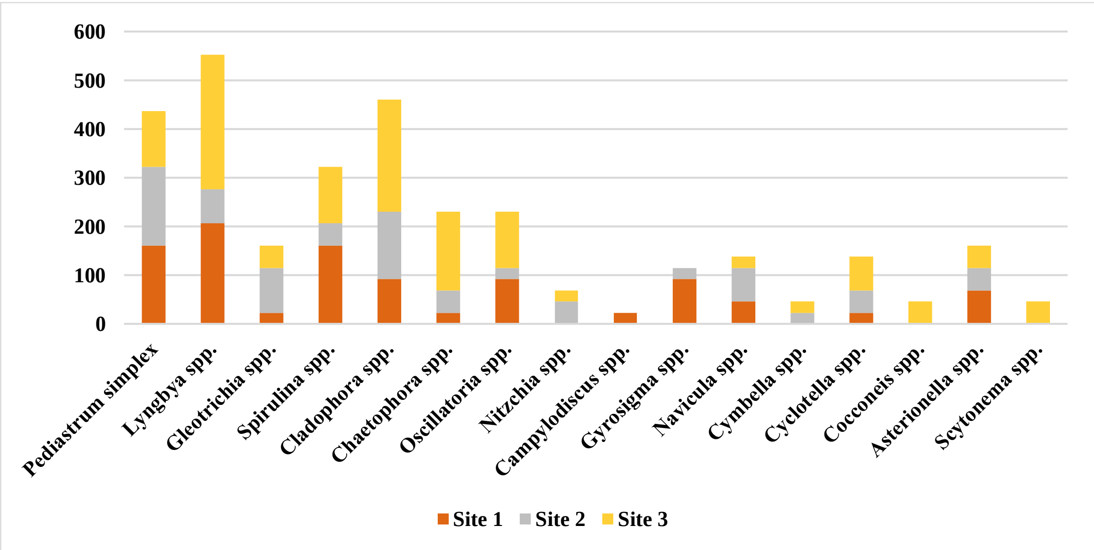

Table 1. **Phytoplankton composition of the middle basin of Ogun River, Abeokuta, Southwest Nigeria**

Phytoplankton	Code	Abundance Site 1	Abundance Site 2	Abundance Site 3	Pooled (N =556)	Relative abundance (%)
Pediastrum simplex	*Ped.sim*	161	161	115	437	13.77
Lyngbya spp.	*Lyng*	207	69	276	552	17.39
Gleotrichia spp.	*Gleo*	23	92	46	161	5.07
Spirulina spp.	*Spir*	161	46	115	322	10.14
Cladophora spp.	*Clado*	92	138	230	460	14.49
Chaetophora spp.	*Chae*	23	46	161	230	7.25
Oscillatoria spp.	*Osci*	92	23	115	230	7.25
Nitzchia spp.	*Nitz*	0	46	23	69	2.17
Campylodiscus spp.	*Camp*	23	0	0	23	0.72
Gyrosigma spp.	*Gyro*	92	23	0	115	3.62
Navicula spp.	*Navi*	46	69	23	138	4.35
Cymbella spp.	*Cymb*	0	23	23	46	1.45
Cyclotella spp.	*Cycl*	23	46	69	138	4.35
Cocconeis spp.	*Cocc*	0	0	46	46	1.45
Asterionella spp.	*Aste*	69	46	46	161	5.07
Scytonema spp.	*Scyt*	0	0	46	46	1.45

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Table 2. **Diversity indices of phytoplankton in the middle Basin of Ogun River, Abeokuta, Southwest Nigeria**

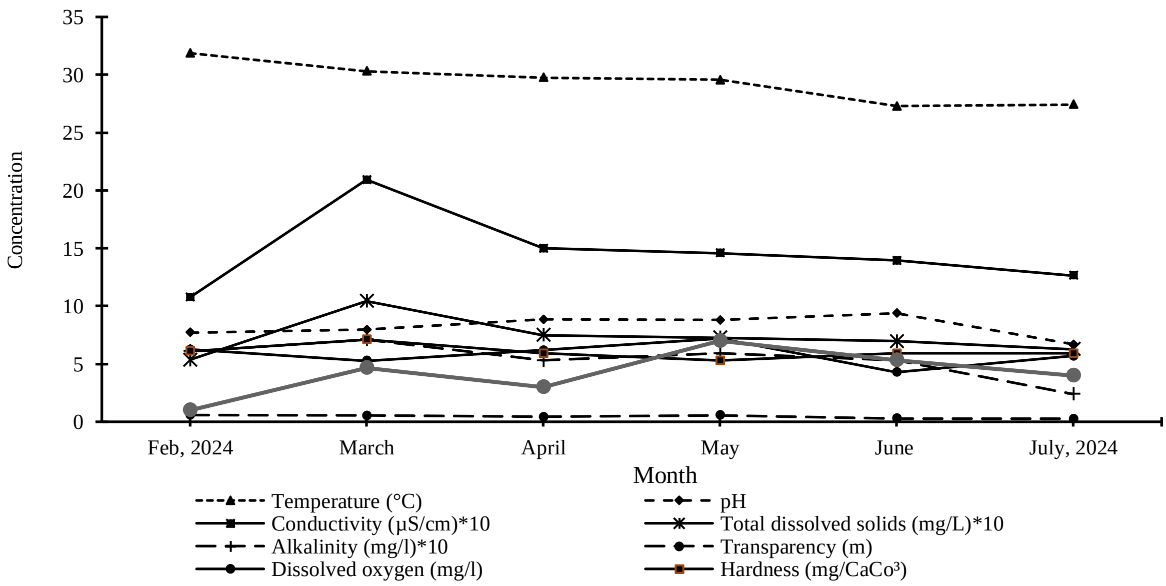
	Site 1	Site 2	Site 3	Pooled	P-value
Taxa_S	12	13	14	16	0.150
Individuals	1012	828	1334	3174	0.220
Dominance_D	0.13	0.11	0.12	0.10	0.300
Simpson_1-D	0.87	0.89	0.88	0.90	0.450
Shannon_H	2.24	2.38	2.35	2.47	0.180
Evenness_e^H/S	0.78	0.83	0.75	0.74	0.270

P < 0.05 Level of significance

Water Quality Parameters in Ogun River

The monthly mean of water quality parameters determined in the Ogun River is shown in *Figure 3*. The parameters include water temperature (°C), pH, dissolved oxygen (mgL^{-1}), electrical conductivity (µs/cm), transparency (m), total dissolved solids (mgL^{-1}), nitrate (mgL^{-1}), phosphate (mgL^{-1}), alkalinity (ppm) hardness (ppm). The analysis was carried out by using Hanna Instruments chemical test kits. The highest water temperature was recorded in February (31.9 °C) and the lowest in June (27.3 °C). The lowest pH (6.7) was recorded in July, and the highest pH (9.4) was recorded in February. The minimum dissolved oxygen of the water was recorded in February (4.3 mgL^{-1}), and the highest was recorded in May (7.2 mgL^{-1}). Electrical conductivity was low in February (10.8 µs/cm) and high in March (20.9 µs/cm). The minimum transparency was recorded in July (0.27 m), and the maximum transparency was recorded in February (0.58m). Phosphate was low in February (1.0 mgL^{-1}) and high in May (7.0 mgL^{-1}). Nitrate was not detected in the water. The highest total alkalinity was recorded in March (7.1 ppm) and the lowest in July (2.4 ppm). Total hardness was high in March (7.1 ppm) and was low in May (5.5 ppm).

Figure 3. **Monthly mean of water quality parameters of the middle basin of Ogun River, Abeokuta, Southwest, Nigeria**



The Canonical Correspondence Analysis (CCA) (*Figure 4*) illustrates the relationships between phytoplankton species and water quality parameters in the Ogun River. Although permutation tests and eigenvalue significance assessments were not performed to statistically validate the axes, the ordination provides preliminary insights into species-environment associations. The abundance of *Pediastrum simplex* was much more influenced by total dissolved solids and conductivity than other organisms. *Navicula* spp. was also influenced by conductivity, but *Pediastrum simplex* was more influenced by conductivity than *Navicula* spp. Temperature and pH positively influenced *Cyclotella* spp., *Cladophora* spp., *Gleotrichia* spp., *Nitzschia* spp., and *Cymbella* spp., but temperature has more influence on *Cladophora* spp. than other organisms. Also, *Cyclotella* spp. was more influenced by pH than other organisms. Transparency positively influenced *Spirulina* spp. much more than alkalinity and hardness. Future studies with increased sample size and replication will enable formal testing to confirm these ecological patterns.

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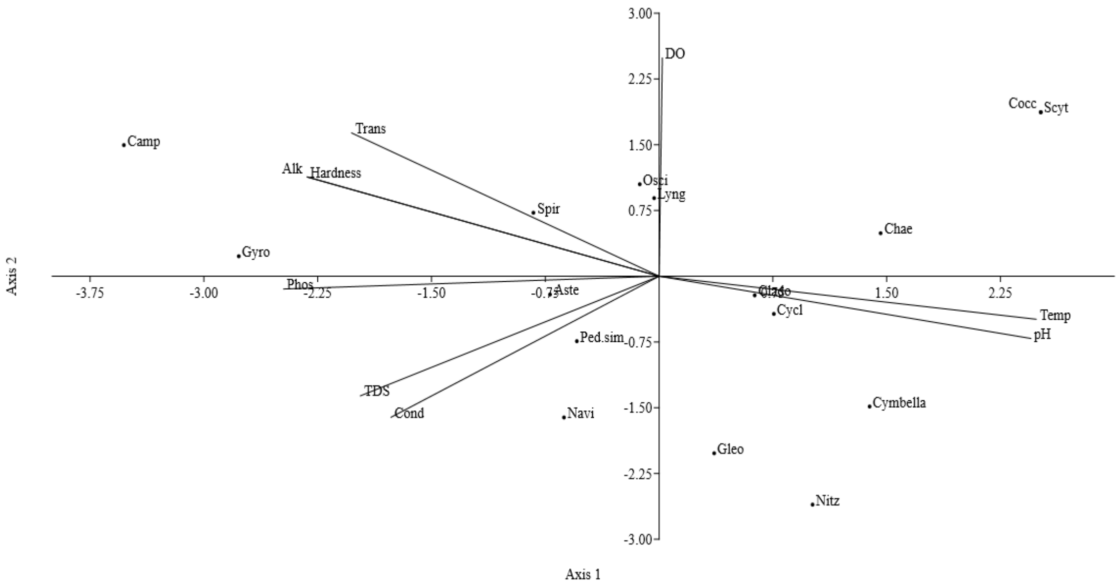
Figure 4. **Canonical correspondence analysis of phytoplankton composition of Ogun River, Abeokuta, Southwest Nigeria**



DISCUSSION

Phytoplankton serve as the primary producers in aquatic ecosystems and represent one of the most varied groups of aquatic organisms. Their growth, productivity, and survival are shaped by biotic and abiotic factors, including water quality parameters like nitrate, temperature, and phosphate. Phytoplankton are distributed throughout the water column based on their size. The findings of this study reveal a diverse phytoplankton assemblage within the middle basin of the Ogun River, characterized by sixteen species spanning ten families. The predominance of Bacillariophyceae, alongside dominant taxa such as *Lyngbya* spp. (17.39%), *Cladophora* spp. (14.49%), and *Pediastrum simplex* (13.77%), reflects typical freshwater phytoplankton community structures in tropical riverine ecosystems influenced by eutrophic conditions and variable physicochemical parameters. Kefas et al. (2025) reported 19 phytoplankton species on the Upper River Benue in Adamawa State, predominantly from Chlorophyceae, Cyanophyceae, and Bacillariophyceae, with moderate species richness and minor site-to-site variation in diversity indices. They noted that local water quality changes influenced the phytoplankton community structure, reflecting similar patterns observed in the present study.

The measured diversity indices, including the Shannon-Wiener and Simpson indices, were relatively consistent across the three sampling sites, with no statistically significant differences ($p > 0.05$). This spatial homogeneity suggests that environmental gradients within the middle basin may be subtle, or the phytoplankton community may possess resilience to moderate environmental fluctuations. Comparable patterns have been reported by Offem et al. (2011) in Nigerian river systems, indicating that phytoplankton communities are often structured more by temporal variability, such as seasonal nutrient pulses, than by spatial heterogeneity at fine scales. The observed species richness and diversity indices in the Ogun River are comparable to those reported in river systems within similar tropical climates. Ogamba et al. (2019) documented similar diversity and community composition patterns along the Nigerian Niger Delta tributaries, emphasizing the role of anthropogenic nutrient input and hydrological regimes in shaping phytoplankton assemblages. The Ogun River's diversity indices (Simpson: 0.87–0.89, Shannon-Weiner: 2.24–2.38) fall within the range reported for Amazon river plumes and Mekong systems, indicating moderate to high species richness typical for tropical floodplain and estuarine rivers (Otsuka et al., 2022; Tran et al., 2023).

The dominance of *Lyngbya* spp. suggests the potential influence of nutrient enrichment from external sources such as agricultural runoff or sewage discharge. Cyanobacteria like *Lyngbya* spp. thrive in nutrient-rich environments and are often associated with eutrophication, a process where high nutrient loads lead to excessive algal growth, disrupting aquatic ecosystems. The presence of *Cladophora* spp. further supports the possibility of high nutrient availability in certain parts of the river. This species thrives in nitrogen- and phosphorus-enriched waters, indicating that nutrient inputs may be affecting the river's ecological balance. The observed dominance of *Lyngbya* spp. and *Cladophora* spp. in the middle basin of the Ogun River likely reflects the influence of key water quality parameters identified through Canonical Correspondence Analysis (CCA). *Lyngbya* spp. abundance was closely associated with higher total dissolved solids and electrical conductivity levels, which may indicate nutrient enrichment or changes in ionic composition favorable to its growth. Paerl & Otten (2013) described how *Lyngbya* spp. thrives in waters with high nutrient loads and altered ionic

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balances, conditions often resulting from anthropogenic runoff or agricultural inputs. Such nutrient enrichment leads to cyanobacterial blooms, which have been implicated in freshwater ecosystem degradation due to toxin production and oxygen depletion (Smith et al., 2019). Similarly, *Cladophora* spp. showed a strong positive relationship with water temperature and pH, suggesting that warmer and more alkaline conditions promote its proliferation. These environmental factors, including elevated total dissolved solids, conductivity, temperature, and pH, align with ecological conditions known to facilitate the dominance of these taxa. Recent research has demonstrated that elevated water temperatures, particularly within the range of 10 °C to 25 °C, and alkaline pH conditions (typically above pH 8) significantly promote the growth and abundance of *Cladophora* spp. in freshwater ecosystems, indicating that warmer and more alkaline waters favor its proliferation (Wang et al., 2024). These conditions facilitate increased photosynthetic rates and biomass accumulation, often signaling eutrophication and modifying habitat complexity for benthic and pelagic communities. The observed linkage is critical, as proliferations of filamentous green algae like *Cladophora* spp. can impact riverine habitat quality and biogeochemical cycling (Wang et al., 2025). Moreover, *Cladophora* spp. dominance may indicate nutrient enrichment conducive to hypoxia in dysoxic conditions, which can destabilize aquatic food webs (Berezina et al., 2022). Although nitrate was not detected and phosphate concentrations varied throughout the sampling period, the influence of conductivity and dissolved solids suggests that other nutrients or ion dynamics could be driving phytoplankton community structure in the river. This inference is supported by studies on tropical freshwater systems where phosphorus strongly influences algal community structure and productivity (Ni et al., 2019). Nonetheless, the influence of conductivity and TDS highlights the importance of other soluble ionic and nutrient inputs (such as ammonium or organic nitrogen) that warrant further investigation, as ionic strength can regulate species composition by affecting osmotic balance and nutrient uptake (Yuan et al., 2024). Also, the results concur with findings from Anyanwu et al. (2023), who linked seasonal physicochemical variations to phytoplankton succession in the Anambra River, Nigeria. Globally, studies such as those by Fernández-González et al. (2022) and Sun et al. (2022) reveal that riverine phytoplankton communities respond predictably to nutrient enrichment, temperature, and pH shifts, supporting the patterns found in this study. The Ogun River's high relative abundance of *Lyngbya* spp. corresponds with increasing cyanobacteria dominance in the Amazon, Mekong, and subtropical rivers globally, where fertilization, runoff, and warm temperatures drive cyanobacteria blooms and ecosystem disruption (Mânica et al., 2023; Lomeo et al., 2025). These findings highlight the importance of monitoring multiple water quality variables when assessing biological indicators of nutrient status and ecosystem health.

The dominance of cyanobacteria raises concerns about the potential for eutrophication in the river. Eutrophication can lead to algal blooms, which reduce dissolved oxygen levels in the water, creating hypoxic conditions that negatively impact fish and other aquatic organisms. In the present study, while elevated nutrient concentrations and the dominance of cyanobacteria indicate that the Ogun River is vulnerable to eutrophication, no large-scale algal blooms were directly observed during the sampling period. Odulate et al. (2017), also reported high cyanobacteria abundance in the Ogun River. This suggests that nutrient enrichment has been a persistent issue in the river, possibly due to ongoing anthropogenic activities. Similar patterns have been observed in other tropical rivers, where cyanobacteria dominate during warmer seasons with higher nutrient loads, while diatoms tend to increase during cooler, low-nutrient periods.

CONCLUSIONS

This study highlights the diverse phytoplankton community present in the middle basin of the Ogun River, with sixteen species identified across three sampling sites. The dominance of Bacillariophyceae and the prevalence of taxa such as *Lyngbya* spp. and *Cladophora* spp. reflect the ecological dynamics shaped by the river's physicochemical conditions. Water quality parameters, particularly total dissolved solids, electrical conductivity, temperature, and pH, were strongly linked to variation in species distribution and abundance, as revealed by the Canonical Correspondence Analysis. Although nitrate was not detected and phosphate levels varied seasonally, the influence of these physico-chemical drivers suggests complex nutrient and environmental regulation of phytoplankton community structure. Statistical comparisons showed no significant differences in diversity indices between sampling sites, indicating a relatively consistent phytoplankton diversity within the middle basin during the study period. However, the preliminary nature of the CCA without permutation testing suggests the need for further investigation with larger sample sizes and temporal replication to confirm these relationships.

Overall, this research underlines the importance of integrating biological assessments with water quality monitoring to better understand freshwater ecosystem health. The findings provide baseline data that can inform sustainable water management and pollution control strategies in the Ogun River system, contributing to improved conservation efforts in Southwest Nigeria. With proper monitoring and conservation efforts, the Ogun River can continue to support diverse aquatic life while providing essential ecosystem services to the surrounding communities. Ensuring the long-term health of the river will require collaborative efforts from stakeholders, including government agencies, local communities, and environmental researchers.

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A key limitation of this study is the absence of essential water quality indicators such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), and total organic carbon (TOC), which are critical for comprehensive and standardized classification of river health. The lack of these key water quality indicators in this study affects the depth and comparability of the study's conclusions regarding overall ecosystem health and pollution status in the Ogun River. As a result, while the biological and basic physicochemical data provide valuable insights, the analysis does not fully capture the overall ecological status of the river according to established international frameworks. Future research should routinely include BOD, COD, TOC, nutrients, and heavy metals, and apply established frameworks such as the EU Water Framework Directive or WHO guidelines to enable comprehensive ecological status assessment, inform best-practice management, and ensure protection of biodiversity and ecosystem services.

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