Quantitative Assessment of Phytoplankton Population Structure and Physicochemical Variability in Lake Buyo, Guessabo Area

Attoungbre Kouakou Séverin*[1], Assi Sonan Romuald[2], N'dri Olga Rosemonde[3]

[1, 3] Laboratory of Biodiversity and Ecology Tropical, Jean Lorougnon Guédé University, P. O Box 150 Daloa, Côte d'Ivoire

[2] UFR Marine Sciences, 01 P. O Box 1800 San Pedro, Côte d'Ivoire

[1]Corresponding author Email: *attoungbreseverin[at]gmail.com*

Abstract: ***The objective of this study is to quantitatively assess the structure of the phytoplankton population of Lake Buyo in the Guessabo area. To this end, spatial measurements of physicochemical parameters and phytoplankton samplings were carried out according to hydrological cycles. Significant variations in physicochemical parameters were recorded between the different hydrological regimes, except for dissolved oxygen, conductivity, and nitrite. For phytoplankton density, the average values fluctuated from 45.85 x 10^6 ± 16.63 Cells/L (station G2) to 78.35 x 10^6 ± 28.83 Cells/L (station G3) in high water and from 41.84 x 10^6 ± 16.66 Cells/L (station G4) to 67.33 x 10^6 ± 29.09 Cells/L (station G1) in low water. Cyanobacteria and bacillariophytes dominated the phytoplankton community at all stations for each of the hydrological regimes. Regarding chlorophyll biomass, average values were significantly higher during low water than during high water. These values varied between 11.04 ± 7.99 µg/L at station G1 and 30.37 ± 21.05 µg/L at station G7, and between 17.08 ± 13.144 µg/L at station G4 and 49.21 ± 37.628 µg/L at station G3. A significant positive correlation was observed between chlorophyll a, phytoplankton density, and conductivity***

Keywords: Phytoplankton, density, chlorophyll *a*, hydrological regime, eutrophic

1. Introduction

Freshwater ecosystems are subject to various sources of pressure, the most important of which is anthropization. The upstream extension of Lake Buyo in the locality of Guessabo in central-western Côte d'Ivoire reflects this reality. In fact, this part of the lake is subject to various activities linked to the conurbations close to the water body (Guessabo and Dibobli) and to the agricultural activities practiced in the catchment area or directly on the banks during low-water periods. This part of the lake is also the main focus for fishing on the Sassandra River to supply the local population as well as the Haut Sassandra and Guémon regions [1]. All these activities are likely to alter the ecological quality of this body of water with high economic potential. Furthermore, according to [1], fish production, which exceeds 500 tons per year, has been falling drastically over the past few years. This drastic drop in fish production can be attributed to strong fishing pressure coupled with a significant deterioration in the ecological quality of this hydrosystem due to its exposure to this anthropic pressure. The ecological quality of this part of the lake has been poorly assessed by physicochemical and biological analyses. Studies carried out to provide information on water quality include those by [2], [3], [4] on physicochemical and microbiological parameters, [5] on phytoplankton composition and trophic status, and [6] on macroinvertebrate population structure. As the ecological quality of water is based on several components of the environment, the algal community represents, in terms of abundance and biomass, the sentinels of aquatic environments. (Explain this sentence better). The development of this community in conditions of stability and favorable nutrient enrichment can be beneficial or detrimental to human health [7]. According to the work of [5], the water quality of this environment appeared eutrophic overall, with a high composition of Chlorophyta, Euglenophyta, Cyanobacteria and Bacillariophyta. The aim of this study is to quantitatively assess the biological structure of the phytoplankton population in relation to physicochemical parameters, with a view to improving the management of this hydrosystem.

2. Material and methods

2.1. Area study

The **area study** is located upstream of the Buyo hydroelectric dam lake on the Sassandra River between (6° 44′ N. 6° 59′ W). This part of the lake acts as a natural boundary between the Haut Sassandra and Guémon regions on the Guessabo-Duekoué axis in western Côte d'Ivoire. The hydrological seasons in this area are characterized by two main trends, namely a rise in water levels from July to December and a fall in water levels from January to June [2]. The sector of the lake sampled is located between 7.00 and 6.96 longitude west and between 6.71 and 6.77 latitude north. This study area is part of the fluvio-lacustrine branch of the Sassandra, which covers a catchment area of 32,462 km^2[8]. The surface area sampled during the course of this work in the upstream zone of Lake Buyo at Guessabo is approximately 17 km^2.

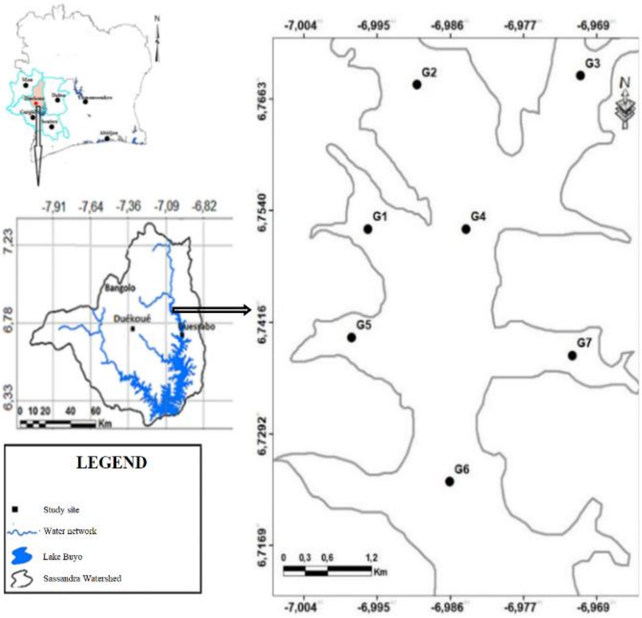

Figure 1: Location of sampling stations on Lake Buyo at Guessabo (G1 to G7)

2.2. Sampling and analysis

Monthly measurements and samples were taken from October 2017 to September 2018 according to hydrological regimes at seven (7) stations located in the upstream part of Lake Buyo. These measurements and samples were taken at the surface. The stations were chosen on the basis of their accessibility and the human activities to which they are subjected. The geographical coordinates of the stations are given in Table 1..

Table 1: Geographical coordinates of stations sampled upstream of Lake Buyo

	Coordinates	
Stations	**(X) dd**	**(Y) dd**
G1	-6.99	6.75
G2	-6.99	6.76
G3	-6.97	6.76
G4	-6.98	6.75
G5	-6.99	6.74
G6	-6.98	6.72
G7	-6.97	6.73

2.2.1. Physicochemical parameters

For physicochemical parameters of the water, some (temperature, pH, dissolved oxygen, conductivity and transparency) were measured in situ between 6.00 and 10.00 am at each site using a HANNA-HI9820 multi-parameter. Other parameters (nitrates, nitrites, total nitrogen and total phosphorus) were analyzed by molecular absorption spectrophotometry according to French standards (T 90-012, T90-023, T 90-013, T 90-110) from samples collected and refrigerated.

2.2.2. Phytoplankton parameters

One-liter samples of water containing the phytoplankton organisms were collected from the surface to a depth of one meter using an integrated sampler. After decanting the samples, the pellet was stored in clean bottles (50 ml) and then fixed with 5% formaldehyde solution for subsequent analyzes.

In the laboratory, after homogenization of the samples, a 10 ml subsample of each sample was sedimented for 8 hours in a sedimentation tank [9]. Phytoplankton cells were counted in the sub-samples after identification at the specific and sub-specific level using identification documents from [10]-[11]-[12]-[13]-[14]-[15]-[16]. Counting was carried out according to the [17] using a Leica inverted microscope (magnification 630 x). 35 fields were observed randomly and without repetition to count the cells. In addition, a filament is considered as an individual and the number of cells is obtained by dividing the length of the filament by the length of a cell, dimensions measured using an ocular micrometer. Similarly, the number of cells in colonial algae is estimated by measuring the dimensions of the colony (shape related to the nearest geometry). For simple shapes, the number of cells is determined at the time of counting. In accordance with AFNOR standard NF EN 15204/T 90-379, a counting accuracy of 5% was achieved by counting (at least) 400 algal objects, as far as possible excluding empty cells (without plasts).

Once the cells had been counted, the absolute density of the different algal groups encountered in a medium was determined from the ratio between the number of cells counted multiplied by the surface area of the sedimentation tank and the surface area observed multiplied by the volume sedimented.

Relative density was estimated by dividing the cell density of each phylum by the total cell density of the environment.
For chlorophyll a, 250 ml of sample was collected and filtered on 0.7 µm porosity GF/F membranes (Whatman) in the field. The filters were stored in aluminum foil in a dark place and transported to the laboratory in a cool box. For pigment extraction, 90% acetone was used. Chlorophyll a was quantified using the spectrophotometric method [18].

2.3. Statistical analyses

Parametric t-tests and one-factor Anova tests at the 5% significance level were carried out on the variables in order to determine the effect of the station and hydrological regime on the descriptors measured.

3. Results

3.1. Physicochemical parameters

Average physicochemical parameters at Lake Buyo stations according to hydrological regime are shown in Figure 2. With the exception of conductivity and pH at a few stations, the averages for the other parameters were much higher at high water than at low water at all stations. Temperature averages during high-water periods ranged from 26.85 ± 1.68°C to 27.74 ± 1.97°C at stations G1 and G3 respectively, while during low-water periods, this parameter ranged from 26.85 ± 1.83°C to 27.35 ± 1.73°C from station G3 to station G4. With regard to average conductivity in high water, the minimum (64.45 ± 11.04 µS.cm-1) was observed at station G2 and the maximum (73.03 ± 8.29

µS.cm-1) at station G3. In low water, conductivity fluctuated between 67.9 ± 9.94 at station G5 and 78.05 ± 11.76 at station G7. In terms of dissolved oxygen, the averages for rising water were high (4.39 ± 1.18 mg/L) at station G5 and high (5.86 ± 1.1 mg/L) at station G7. Low-water averages for this parameter were low (4.02 ± 2.09 mg/L) at station G7 and high (4.7 ± 2.18 mg/L) at station G2. For pH during high water, the averages fluctuated between 6.16 ± 0.16 at station G7 and 6.29 ± 0.14 at station G5, but during low water, the extreme averages (5.87 ± 0.68 and 6.65 ± 1.01) were observed at stations G1 and G7 respectively. With regard to transparency, the averages in high water varied from 0.5 ± 0.31 cm (G7) to 0.66 ± 0.63 cm (G2), while in low water the averages fluctuated between 0.3 ± 0.08 cm at station G7 and 0.84 ± 0.55 cm at station G2. As for total phosphorus during rising water, the averages were minimum (8.552 ± 4.054 mg/L) at station G3 and maximum (16.135 ± 9.942 mg/L) at station G4. In low water, total phosphorus averages fluctuated from 0.643 ± 0.469 mg/L to 0.983 ± 0.703 mg/L from station G5 to station G4. High-water nitrate averages varied from 2.8 ± 2.064 mg/L at station G7 to 5.6 ± 3.271 mg/L at station G1. Low-water averages for this parameter ranged from 1.52 ± 1.376 mg/L at station G6 to 2.59 ± 1.396 mg/L at station G1. For nitrite, high-water averages ranged from 0.016 ± 0.014 mg/L at station G6 to 0.036 ± 0.023 mg/L at station G1. Low-water averages for this parameter ranged from 0.028 ± 0.02 mg/L at station G7 to 0.039 ± 0.024 mg/L at station G6. For total nitrogen in high water, the smallest (22.198 ± 7.584 mg/L) and largest (27.937 ± 8.093 mg/L) averages were recorded respectively at stations G3 and G4. While in low water, the averages were obtained for the minimum (6.3685 ± 6.09 mg/L) at station G6 and the maximum (8.259 ± 6.683 mg/L) at station G2were obtained for the minimum (6.3685 ± 6.09 mg/L) at station G6 and the maximum (8.259 ± 6.683 mg/L) at station G2

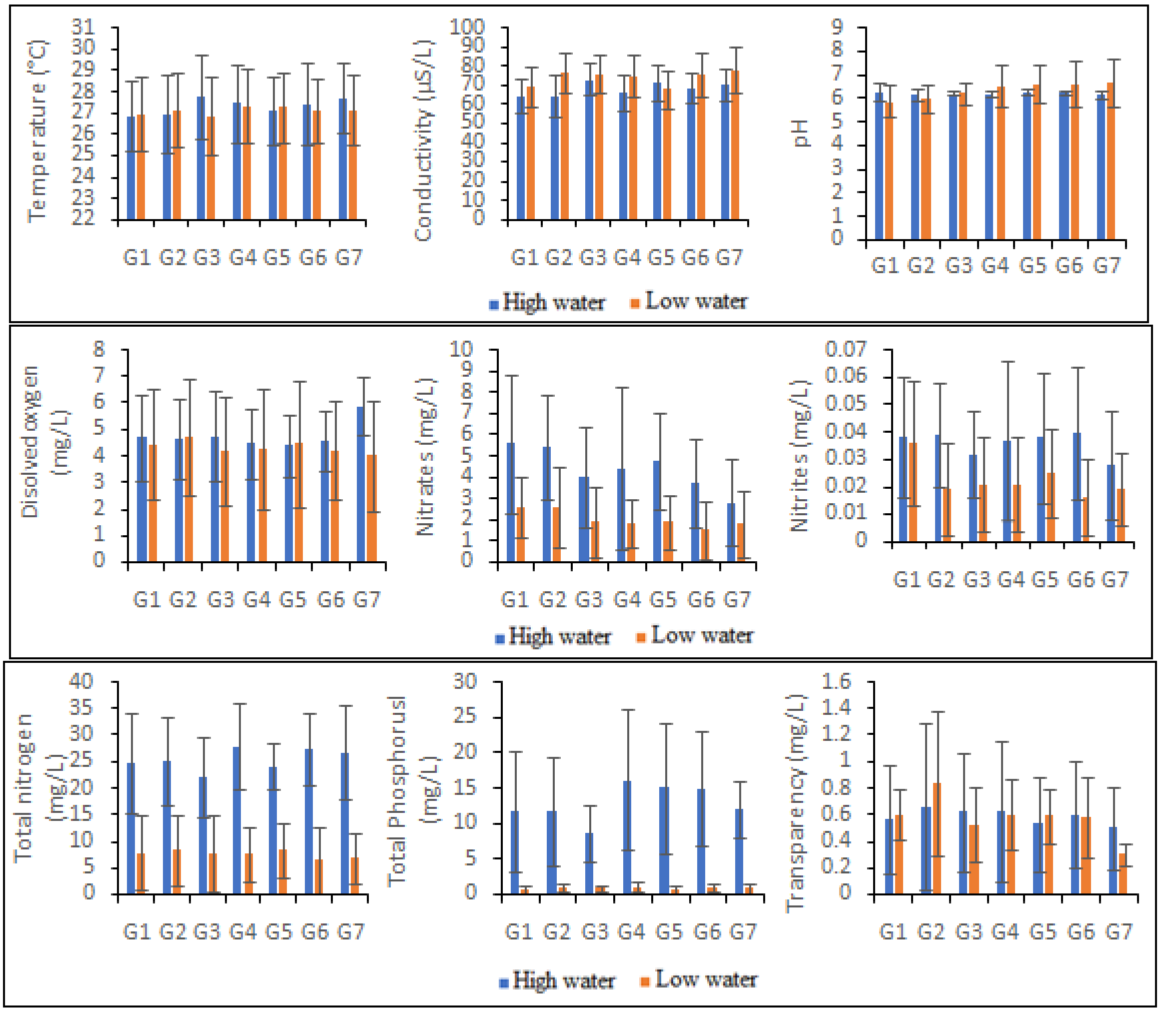

Figure 2: Spatial variations in physicochemical parameters during the hydrological seasons. G1-G7: stations

3.2. TN/TP ratio

The TN/TP ratios of the low-water stations are high compared with those of the high-water stations, but remain well below the threshold value of 20, suggesting a limitation of nitrogen in the water upstream of Lake Buyo.

Table 2: Average values of the TNt/TP ratio at the various stations and hydrological regimes.

Stations	High water	Low water
G1	1.99	5.77
G2	2.15	4.20
G3	2.21	7.18
G4	1.74	3.27
G5	1.81	2.78
G6	1.98	2.50
G7	2.14	3.39

3.3. Analysis of spatial variations in physicochemical parameters according to hydrological regime

According to the tests carried out, the physicochemical parameters varied significantly from one hydrological regime to another (t-test, $p < 0.05$) except for dissolved oxygen, nitrite and conductivity. No parameter varied significantly from one station to another (Anova, $p > 0.05$) (Table 3).

Table 3: Statistical tests carried out on the various physicochemical parameters

	Hydrological regime effect	Station effect
parameters	t test (p)	Anova (p)
Temp	0.0002*	0.99
Cond	0.95	0.636
pH	0.0008*	0.2
OD	0.64	0.99
NO_3^-	0.002*	0.08
NO_2^-	0.09	0.91
Nt	0.0005*	0.99
Pt	0.00001*	0.98
Trans	0.0002*	0.85

*: significant variance

3.4. Phytoplankton densities

Phytoplankton density values during rising water ranged from 45.85 x 10^6 ± 16.63 Cells/L (station G2) to 78.35 x 10^6 ± 28.83 Cells/L (station G3) (Figure 3). During the low-water period, phytoplankton density values varied from 41.84 10^6 ± 16.66 Cells/L (station G4) to 67.33 x 10^6 ± 29.09 Cells/L (station G1). No significant differences were recorded between stations (Anova, *p* (0.57) > 0.05) or between hydrological regimes (t-test, *p* (0.4) > 0.05)

Figure 4 and table 4 show the relative densities of the different phyla and the dominant phytoplankton taxa in proportion. The proportions of Cyanobacteria and Bacillariophyta individuals were dominant during the hydrological regimes at over 20% in each of the stations (Figure 4). In high water, Cyanobacteria dominated, while Bacillariophyta dominated in high water. 11 dominant species were observed in Lake Buyo (Table 4), of which *Microcystis aeruginosa* and *Aulacoseïraambigua* were the most dominant Cyanobacteria and Bacillariophyta, respectively.

3.5. Chlorophyll biomass

Figure 4 and table 4 show the relative densities of the different phyla and the dominant phytoplankton taxa in proportion. The proportions of Cyanobacteria and Bacillariophyta individuals were dominant during the hydrological regimes at over 20% in each of the stations (Figure 4). In high water, Cyanobacteria dominated, while Bacillariophyta dominated in high water. 11 dominant species were observed in Lake Buyo (Table 4), of which *Microcystis aeruginosa* and *Aulacoseïraambigua* were the most dominant Cyanobacteria and Bacillariophyta, respectively.

3.6. Chlorophyll biomass

Chlorophyll *a* averages in high water varied from 11.04 ± 7.99 µg/L at station G1 to 30.37 ± 21.05 µg/L at station G7, while in low water, chlorophyll biomass ranged from 17.08 ± 13.144 µg/L at station G4 to 49.21 ± 37.628 µg/L at station G3 (Figure 5). This parameter varied significantly only between hydrological regimes (t-test, ($p= 0.004$) < 0.05).

Figure 4 and table 4 show the relative densities of the different phyla and the dominant phytoplankton taxa in proportion. The proportions of Cyanobacteria and Bacillariophyta individuals were dominant during the hydrological regimes at over 20% in each of the stations (Figure 4). In high water, Cyanobacteria dominated, while Bacillariophyta dominated in high water. 11 dominant species were observed in Lake Buyo (Table 4), of which *Microcystis aeruginosa* and *Aulacoseïraambigua* were the most dominant Cyanobacteria and Bacillariophyta, respectively.

3.7. Chlorophyll biomass

Chlorophyll *a* averages in high water varied from 11.04 ± 7.99 µg/L at station G1 to 30.37 ± 21.05 µg/L at station G7, while in low water, chlorophyll biomass ranged from 17.08 ± 13.144 µg/L at station G4 to 49.21 ± 37.628 µg/L at station G3 (Figure 5). This parameter varied significantly only between hydrological regimes (t-test, ($p= 0.004$) < 0.05).

3.8. Correlation between physicochemical and biological parameters

A strong correlation was observed between chlorophyll a and phytoplankton density ($r = 0.85$) as well as conductivity ($r = 0.73$), in contrast to nutrient salts and transparency (Table 5).

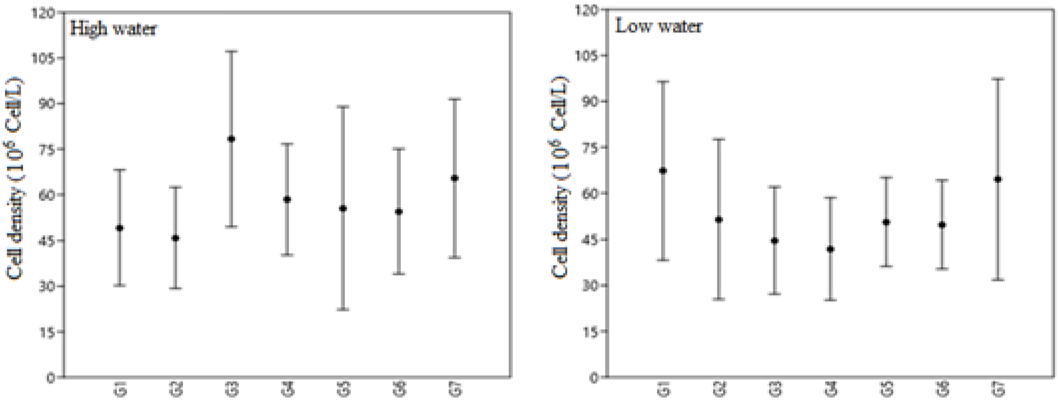

Figure 3: Average values of phytoplankton density at stations during hydrological regimes

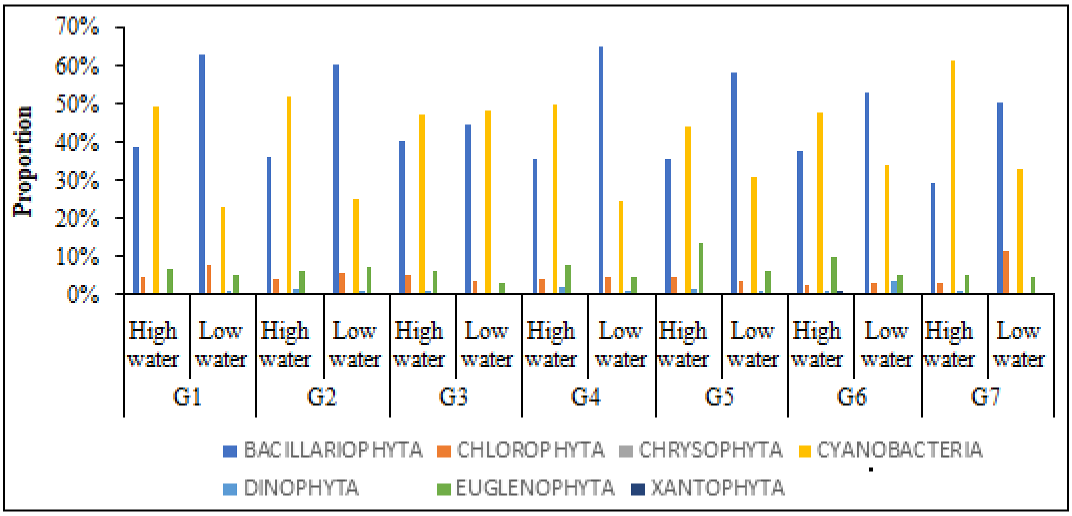

Figure 4: Spatial distribution of the relative density of phytoplanktonic phyla according to hydrological regime. G1-G7: stations

Table 4: Contribution of dominant species to total phytoplankton density by station and hydrological regime in Lake Buyo.

	Bacillariophyta(%)					**Cyanobacteria (%)**					
Stations and hydrological regimes	*Asfo*	*Auam*	*Auamj*	*Augra*	*Augr*	*Miae*	*Plli*	*Phar*	*Mete*	*Psli*	*Sysp.*
G1	3	5	6	5	3	18	7	0	3	1	4
G2	1	7	4	5	4	8	5	1	1	31	3
G3	3	11	1	4	3	38	1	2	1	2	4
G4	4	7	5	3	10	33	1	1	1	1	0
G5	1	3	4	3	5	41	3	1	1	2	2
G6	1	5	4	5	7	46	1	2	2	1	0
G7	1	5	1	7	11	41	3	7	3	6	1
High Water	4.7	5.2	2.8	1.7	9.3	6.3	2.7	1.3	1.2	3.5	1.7
Low Water	0	11	7	1	4	11	1	0	4	1	0

Asfo: Asterionellaformosa, Auam: Aulacoseiraambigua, Auamj: Aulacoseiraambigua var. japonica,Augr:Aulacoseiragranulata, Augra: Aulacoseiragranulata var. angustissima Apco: Aphanocapsaconferta, Miae: Microcystis aeruginosa, Plli: Planktolyngbyalimnetica, Phar: Phormodiumarticulatum, Mete: Merismopediatenuissima, Psli: Pseudanabaenalimneticus, Sysp: Synechococcus sp.

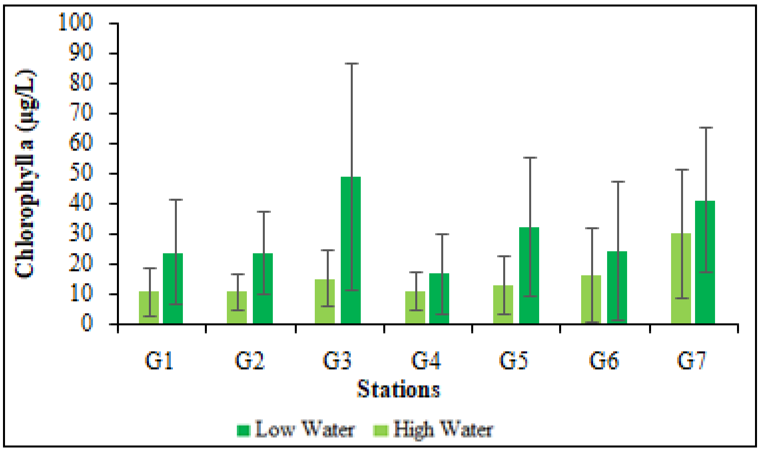

Figure 5: Spatial variations in chlorophyll *a* averages according to hydrological regimes

Table 5: Personcorrelation matrix between nutrients, biomass and density

	Temp									
Cond	0.59	Cond								
pH	0.62	0.38	pH							
OD	-0.55	-0.45	-0.86	OD						
$NO3^{-}$	-0.72	-0.78	-0.81	0.84	$NO3^{-}$					
NO_2^{-}	-0.70	-0.95	-0.46	0.44	0.76	NO_2^{-}				
TN	0.11	-0.05	0.38	-0.50	-0.23	-0.07	Nt			
TP	0.33	-0.20	0.68	-0.56	-0.30	0.02	0.79	Pt		
Trans	-0.05	-0.36	-0.56	0.81	0.62	0.19	-0.26	-0.16	Trans	
Dens	-0.18	0.41	0.05	-0.40	-0.34	-0.15	-0.13	-0.40	-0.82	Dens
Chla	0.07	0.73	0.29	-0.46	-0.56	-0.55	-0.16	-0.36	-0.74	0.85

NO_3^{-}: Nitrate, NO_2^{-}: Nitrite, TN: Total nitrogen, TP: Total phosphorus, Chla: Chlorophyll *a*, Dens: Density

4. Discussion

The averages of the physicochemical parameters studied were homogeneous between the study stations. These parameters varied significantly from one hydrological regime to another, with the exception of conductivity, dissolved oxygen and nitrite. Overall, the water remains warm, slightly acidic, less oxygenated and transparent, with high nutrient values. The stations therefore have approximately the same physicochemical characteristics. This similarity in the values of the physicochemical parameters could be linked to the interconnection between the stations via the exchange flow. The average values for temperature were higher in the upper water than in the lower water in the lake. This observation could be explained by the fact that the air temperature linked to solar radiation is at its highest during this period. In fact, during the period of rising tide, the warm air and the absence of canopy cover help to warm the water. The average temperatures in this study are within the range of those in tropical Africa (25°C-30°C). The average values for dissolved oxygen appeared to be low and homogeneous depending on the hydrological regime. These low values are thought to be due to the consumption of dissolved oxygen during respiration following the rise in temperature. During the night, the almost invasive aquatic plants (microalgae and macrophytes) in the water body absorb dissolved oxygen and release CO_2, which would explain the low dissolved oxygen and high CO_2 levels during the sampling hours. The carbonic acid (H2O3) produced by hydration of the CO_2, the ionization of which releases hydrogen ions (H^+), causes the pH to fall [19], hence the acidity. The average values for these two parameters are below the guide values proposed by the [20] and those from the work of [21] on Lake Labion in Cote d'Ivoire. This difference is thought to be due to the eutrophic conditions in our environment. Lake Buyo shows homogeneous variations in mean electrical conductivity of less than 100 µS/cm, regardless of the hydrological regime. These conductivity values were close to those obtained in certain lakes in Côte d'Ivoire from studies by [22] on the Taabo lakes and by [23] on the waters of Lake M'bakré. According to [24], electrical conductivity provides information on the degree of mineralization of a water body. As the nature of the bedrock is a function of the mineralization of a water body, electrical conductivity therefore reflects the geological characteristics of the catchment [25]. The low conductivities recorded in the water could be explained by the flow of runoff during the rise in water levels and by the nature of the geological bedrock, which is made up of metamorphic rock. As for transparency, although the average value for flooding is higher than for deflooding, the values remain low. These average values are linked to suspended solid particles from urban run-off and erosion in agricultural areas. In addition, navigation for fishing and transport as well as the decomposition of quasi-invasive aquatic vegetation would contribute to reducing water transparency. Our results corroborate those of [26] on the Ayamé 2 dam lake, [4] and [6] on Lake Buyo in the same study area. The high concentrations of nutrient salts upstream of Lake Buyo, particularly during periods of high water, are thought to result from the leaching of fertilizers and plant protection products used in the surrounding fields, as well as from the release of sediments and bird droppings. The levels of nutrient salts obtained in this study are similar to those found in the work of [27] on small dams in northern Côte d'Ivoire. According to this author, the nutrient enrichment of these ecosystems is caused in part by exogenous but also endogenous inputs.

The TN:TP ratio of water from stations upstream of Lake Buyo remains well below the 20-threshold value proposed by [28], suggesting nitrogen limitation. However, based on the logic of [29], this report does not provide any information that would allow the true identification of potentially limiting nutrients, as these elements are both present in excessive quantities. In such conditions, [30] recommend taking into account the concentration that can limit assimilation by phytoplankton, using the dynamics of nutrient assimilation. In this case, using the technique of concentrations and ratios, the determination of limiting elements can only be potential. Based on this principle, by comparing our total nitrogen and total phosphorus values with the limit values in the literature (< 50mg/L for TN and < 4 mg/L for TP), it emerges that phosphorus is the limiting factor. These nutrients are essential to organic matter and play a part in the composition of cell proteins.

Algae use them for their development, hence the high density of phytoplankton in the lake. In almost all cases, with the exception of stations G1 and G2, samples collected during high water had higher phytoplankton densities than those collected during low water. The phytoplankton communities of each hydrological regime are dominated by Cyanobacteria and Bacillariophyta at all stations. The dominance of each of these two groups would be linked to the eutrophic conditions of the lake already characterized by previous work [5], [6]. Similar observations were made by [31] in Lake Tana in Ethiopia and by [32] in Lake Dohou in Côte d'Ivoire. Individuals of colonial Cyanobacteria such as *Microsystisaeroginosa* were the most abundant at all stations during flooding, unlike filamentous Bacillarophyta such as *Aulacoeïraambigua* during flooding. The high density of this group during flooding is superimposed on the high concentrations of nutrients during this period, which is probably linked to nutrient inputs from crops treated with nitrogen and phosphorus. In addition, this group has a competitive advantage over other phyla in eutrophic conditions. In fact, the low dissolved oxygen concentrations obtained in this study as a result of eutrophication could favor Cyanobacteria, since they are known to be tolerant of such conditions. In addition, the reduced availability of light (low transparency) due to suspended matter and quasi-invasive vegetation contributed to their proliferation in the groups through their ability to migrate to the surface in search of sunlight. This capacity gives certain species of the Nostacale genus the ability to fix atmospheric nitrogen from their structures. The very strong contributions of colonial and filamentous taxa such as *Microcystis aeruginosa* and *Pseudanabaenalimneticus* give the image of a eutrophic ecosystem. According to [33], the proliferation of Cyanobacteria in eutrophic environments is not only due to the increase in nutrient levels, but also to the consequences of eutrophication. As for the low-water period during which Bacillariophyta dominated the population, this corresponds to nutrient concentrations lower than those in high water. In addition to nitrogen and phosphorus, this result could be explained by another interesting factor to consider, namely silica. Silica is a compound that forms part of the external structure of diatoms, the frustule. The presence of this compound could come from the soil and the geological substratum composed of metamorphic rocks through leaching or the release of muddy sediments. This compound could also come from Hippopotamus excrement, which is very frequent in high water (December-January). Our results are similar to those obtained on Lake Dohou in Côte d'Ivoire by [32] and on the El Kansera reservoir in Morocco by [34].

As regards chlorophyll biomass, the averages were heterogeneous, unlike cell density, where the values remained homogeneous. However, there was a strong correlation between them (r = 0.8). The chlorophyll a level obtained in low water are higher than those found in the work of [35] on Lake Taabo and [36] on the Adzopé reservoir. This result may be due to the high photosynthetic activity upstream of Lake Buyo during this period. This photosynthetic activity is more closely linked to conductivity (r = 0.73), which reflects the mineralization of the environment during low water. Temperature, in relation to this factor (r = 0.59), stimulated and accelerated this chemical reaction, hence the high concentration of chlorophyll *a*.

5. Conclusion

Despite the heterogeneity of the average values of the physicochemical parameters between the hydrological regimes, the waters upstream of Lake Buyo are warm, slightly acidic, less oxygenated, eutrophic and turbid. The phytoplankton community structure is very dense in the lake and dominated by Cyanobacteria individuals followed by Bacillariophyta during each of the hydrological regimes. As for chlorophyll biomass, the average values were significantly high in low water. A strong correlation was observed between phytoplankton cell density and chlorophyll biomass. In view of the conclusions of previous studies reporting eutrophication of this environment, plus the high dominance of Cyanobacteria with *Microsystis aeruginosa* potentially toxic to human health, the ecological quality is alarming. Faced with this situation, an action plan and local sustainable development strategies need to be put in place to preserve it.

References

[1] **K. S. Kra.** Le développement de la pêche en Côte d'Ivoire: le cas de la pêche continentale dans la sous-préfecture de Guessabo. *Revue de Géographie Tropicale et d'Environnement*, I, pp. 37 – 45, **2016.**

[2] **V. Mambo, A. S Tidou, Y. B. Ossey& P. Ohouenou.** Evaluation de l'état trophique de Buyo (Côte d'Ivoire): aspects physico-chimiques et biologies. *Journal de la Société Ouest - Africaine de Chimie*, XI, pp. 95 – 135, 2001.

[3] **Y. B. Ossey, V.Mambo, A. S. Tidou, P. V. Houenou.** Étude analytique des caractéristiques chimiques d'un lac eutrophe en milieu tropical: la conductivité comme indicateur de trophie du lac de Buyo (Côte d'Ivoire), *Journal de la Société Ouest - Africaine de Chimie*, XXV, pp. 87-108, 2008.

[4] **K. B. Kouame, K. S. Konan, K. S. Attoungbre, K. F. Konan, K. C. BOUSSOU, K. M. Kouame.** Physicochemical and Bacteriological Parameters of Surface Water Quality in part of West Côte d'Ivoire: Potential Resources for Drinking Water Production (Guessabo Lake), *Journal* of *Applied Environmental* and *Biological sciences,* IX, pp. 17–29, **2019a**:

[5] **K. S. Attoungbre, J. E Niamien-Ebrottie, K. F. Konan, K. C. Boussou, K. M, K. B. Kouame, N. G. Aliko, A. N. Yoboue, K. S. Konan, G. Gourène.** Phytoplankton Composition and trophic state of Guessabo lake (Upstream in Buyo lake, Ivory Coast). Journal of Applied Biosciences, CXLIII, pp. 14659-14680, **2019.**

[6] **A. H. Kouame, K. S. Attoungbre, K. C. Boussou, K. M. Kouame, E. O. Edia (2022).** Structure of the macro invertebrate population of Lake Buyo (Guessabo, west Côte d'Ivoire). *World Journal of Advanced Research and Reviews,* XV (02), pp. 682-692, 2022.

[7] **N. Chomérat, S. Fayolle, A. Cazaubon.** Phytoplankton dynamics in a hypertrophic brackish lake in the South of France, *SIL Proceedings*, 1922-2010, XXIX (1), pp. 491-496, **2005.**

[8] **K. P. Die.** Renforcement de l'alimentation en eau potable de la ville de Daloa à partir du barrage de Buyo en Côte d'Ivoire. Institut International d'Ingénierie de l'Eau et de l'Environnement, Ouagadougou, Burkina-Faso, **2006.**

[9] **T. Feret, C. Laplace-Treyture.** IPLAC: L'Indice Phytoplancton LACustre: Méthode de développement, description et application nationale 2012. Rapport final, Irstea Bordeaux, France, **2013.**

[10] **M. T. Philipose ().** ChlorococcalesIndian Council of Agricultural Research, Indian, **1967**

[11] **P. Compère.** Algues de la région du lac Tchad. VII. Chlorophytes: 3ème partie: Desmidiées. Cah. *O.R.S.T.O.M. Série Hydrobiologie,* XI (2), pp. 77-177, **1977**.

[12] **A. Couté, A. Iltis.** Ultrastructure de la logette de Trachelomonas (Algae, Euglenophyta) récoltés en Côte d'Ivoire. *Revue Hydrobiologie Tropicale,* XIV (2), pp. 115 – 133, 1981.

[13] **J. Komárek, B. Fott.**Chlorophyceae (Grünalgen) Ordnung: Chroococcales, in DasPhytoplankton des Sübwassers, G. Huber-Pestalozzi (Ed.), Schweizerbart'scheVerlagsbuchhandlung. Deutschland, **1983.**

[14] **G. Uherkovich.** A Scenedesmuszöldalganemzetség (Chlorococcales, Chlorophyceae) különöstekintettelmagyarországielöfordulásútaxonjaira . Magyar AlgológiaiTársaság, Magyarország, **1995**.

[15] **A. Ouattara.** Premières données systématiques et écologiques du phytoplancton du lac d'Ayamé (Côte d'Ivoire). University of Leuven, Belgium, **2000.**

[16] **J.Komárek, K. Anagnostidis.**Cyanoprokaryota -2. Teil/ 2nd Part:Oscillatoriales, in Süβwasserflora von Mitteleuropa, B. Büdel., L. Krienitz., G. Gärtner, & M. Schagerl (Eds.), Elsevier SpektrumAkademischerVerlag, München, **2005.**

[17] **Utermöhl H.** Zur Ver vollkommnung der quantitativenPhytoplankton-methodik. *InternationaleVereinigungFuertheoretischeUndeamgewandteLimnologie*, IX, pp. 1 - 39, **1958**.

[18] **Lorenzen C.J. (1967).** Determination of chlorophyll and pheopigments: Spectrophotometric equations. *Limnology and Oceanography*, XII, pp. 343 - 346, **1967**.

[19] **M. Scheffer,, E. H. Van Nes.** Shallow lakes theory revisited: Various alternative regimes driven by climate, nutrients, depth and lake size. *Hydrobiologia*, DLXXXIV, pp. 455-466, **2007**.

[20] WHO (World Health Organization). Water, Sanitation and Health Team. Guidelines for drinking-waterquality. I, Recommendations, 3rd ed. World Health Organization, 2004.

[21] **E. Odjohou., M. Amani, G. Soro, S. Monde**. Caractérisation physico-chimique des eaux d'un système lacustre du cordon littoral ivoirien: cas du lac Labion. *International Journal and Chemical Sciences*, XIV (5), pp. 1878-1892, 2020.

[22] **N. Koné, A. S. N'DA, K. B. Kien, G. F dit H. Boguhé, S. Berté**. Physico-chemical characterization of the waters of the Kossouhydroelytric dam, Bandama river, Côte d'Ivoire. *Revue Ivoirienne des Sciences et Technologies*., XXXIX, pp. 55-69, **2022.**

[23] **C. A. Aka, N. Keumean.K., N. Aka.**Physico-Chemical Characterisation of the Waters of Lake M'bakre, South of Abidjan, Côte d'Ivoire. *International Journal of Innovation and Scientific Research*, LIX (2), pp. 59-68, **2022.**

[24] **E. Derwich, L. Benaabidate, A. Zian, O. Sadki, D. Belghity**, Caractérisation physico-chimique des eaux de la nappe alluviale du Haut Sebou en aval de sa confluence avec Oued Fes, *Larhyss Journal*, 8, pp. 101-112, **2010.**

[25] **V. Clément, G. Ouimet.** Programme d'évaluation et de surveillance des lacs. Rapport présenté par Biofiliainc. pour la ville de Mont-tremblant, dossier 2004-1144, Québec, Canada, 2004.

[26] **Y. E. Adou, K. G Blahoua, Z. M. Gogbé, V. N'Douba. ().** Caractérisation physico-chimique des eaux d'un lac situé entre deux barrages hydroélectriques: Ayamé 2 (Côte d'Ivoire). *European Journal of Scientific Reseach*, CXLIX (4) pp. 451-461, **2018.**

[27] **R. Arfi, M. Bouvy, P. Cecchi, M. Pagano, L. Saint-Jean, S. Thomas**. Facteurs limitant la productivité phytoplanctonique dans 49 petits barrages. *In*: L'eau en partage: Les petits barrages de Côte d'Ivoire, IRD, France, **2007**

[28] **S. J Guildford, R. E. Hecky**. Total Nitrogen, total phosphorus and nutrient limitation in lakes and oceans. *Limnology and Oceanography* XLV (6), pp. 1213-1223, **2000.**

[29] **J. C. Lacaze**. L'eutrophisation des eaux marines et continentales. Ellipses, Paris, **1996**.

[30] **Q. Dortch, T. E. Whitledge**. Does nitrogen or silicon limit phytoplankton production in the Mississippi River plums and nearby regions? *Continental Shelf Research*, XII (11), 1293- 1309,1992.

[31] **A. Wondie, S. Mengistu., J. Vijverberg, E. Dejen.** Seasonal variation in primary production of a large high altitude tropical lake (Lake Tana, Ethiopia):

effects of nutrient availability and water transparency. *Aquatic Ecology*, XLI, pp. 195-207, **2007.**

[32] **K. S. Attoungbré, J. E. Niamien-Ebrottie, K. M. Kouame, K. C. Boussou, N. G. Aliko & K. F. Konan**. Typology of the Phytoplankton Community of Dohou Lake, Drinking Water Supply Source in Duékoué Town (Western Côte d'Ivoire). *Journal of Environment and Ecology*. XI (1), pp. 1-18, **2020.**

[33] **Lavoie Isabelle., Laurion Isabelle., Warren Annabelle et Vincent Warwick)**. Les fleurs d'eau de cyanobactéries, revue de littérature. Rapport 916,Institut national de la recherche scientifique, Québec, Canada, **2007.**

[34] **B. D. Fqih, R Berrada, A. Benzekri, E. Jabrey.** Evolution saisonnière des peuplements phytoplanctoniques dans la lac-reservoire El Kansera (Maroc), en relation avec les paramètres abiotiques. *Hydroécologie appliquée*, 12 (1-2), pp. 207-231, **2000.**

[35] **N. Groga.** Structure, fonctionnement et dynamique du phytoplancton dans le lac de Taabo (Côte d'Ivoire). Université de Toulouse, Toulouse, France, **2012**.

[36] **M. P Adon.).** Variations spatiale et saisonnière du phytoplancton de la retenue d'eau d'Adzopé. Université NanguiAbrogoua, Abidjan, Côte d'Ivoire, **2013**.

Author Profile

Attoungbre Kouakou Séverin, Jean Lorougnon Guédé University, Laboratory of Biodiversity and Ecology Tropical PhD

Assi Sonan Romuald, University of San Pedro, UFR Marine Sciences, PhD

N'dri Olga Rosemonde, University, Laboratory of Biodiversity and Ecology Tropical, PhD