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Phytoplankton characterization and the state of eutrophication of Mefou Lake (Yaounde, Cameroon)

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Abstract
The aim of the study was to determine the diversity and the distribution of the phytoplankton of Mefou Lake of Yaounde. The study was conducted from May 2019 to May 2020. The pelagic area was sampled in seven stations. A total of 79 species were identified, including approximately 29.87% of Cyanophyceae, 18.18% of Bacillariophyceae, 14.28% of Chlorophyceae and Euglenophyceae respectively, 06.49% Mediophyceae, 03.89% of Dinophyceae, 02.59% of Conjugatophyceae, Coscinodiscophyceae, Cryptophyceae, and Trebouxiophyceae respectively, 01.29% of Pyramimonadophyceae and Ulvophyceae respectively. Cyanophyceae are the most common and abundant class in samples taken from lake stations. The genus *Eudorina* is common to all stations. The transparency of the water varies between 0.35 m and 0.40 m in the stations. Mefou Lake has a uniform eutrophic state and poor ecological status.

Keywords: diversity, eutrophication, freshwater, mefou lake, phytoplankton, yaounde

1. Introduction

Surface water occupies most of the Earth's surface. About 98% of these waters are marine waters. The remaining 2% is continental waters represented by rivers, lakes and ponds. Because of their multiple uses, these inland waters are of great importance for human activities [1]. Inland waters attract and concentrate many populations for their activities, which in turn must ensure their management and sustainability. In the face of the current population explosion, freshwater resources are exhaustible, and human activities are one of the major causes of stress in aquatic ecosystems [2]. The deterioration of the water resource is mainly due to point and diffuse pollution and changes in physico-chemical characteristics [3, 4]. Changes in communities may result directly from the introduction and/or disappearance of species induced more or less directly by human activities [5]. The consequences of biodiversity erosion and habitat alteration on ecosystem goods and services are at the heart of the concerns of researchers, policy makers and managers [6, 7].

In continental waters, phytoplankton is the basis of the food chain. This phytoplankton can form algal bloom as a result of the proliferation of one or a few species under favorable hydroclimatic conditions and in particular the imbalance of control by the nutritive resource or grazing [1].The specific composition of the phytoplankton communities, the relative abundance of different species and the dominance of one population over another are traits and phenomena that are constantly evolving and characterize phytoplankton successions [8].

Mefou Lake is a complex ecosystem by its size, which depends not only on the functioning of its internal components, but also on local constraints (inputs from its watershed). To date, the state of Mefou Lake, where the wastewater from the various dump sites of the agglomerations is dumped and the leaching of the surrounding lands, is quite demonstrative of the impact of the action of the man. Since then, it has undergone strong human pressure due to untreated wastewater discharges from housing estates and those emanating from other structures bordering the water body [9, 10]. In recent years, a proliferation of microalgae has occurred in the pelagic zone of the lake, which gives the water a green color and floating macrophytes develop. Such growth of phytoplankton and macrophytes are likely the first symptoms of "poor" ecosystem health.

The phytoplankton flora of Mefou Lake is not known. The monitoring of phytoplankton population evolution and the trophic functioning of the hydrosystem has not been carried out at Mefou Lake. The intensification of agricultural activities and rampant urbanization in the Mefou watershed are favorable factors for erosion phenomena, which have a negative influence not only on the ecological quality of the hydrosystem but also on the biological communities in general, and more particularly the planktonic microalgae [11]. However, the understanding of the dynamics of any alluvial environment lies in the interactions between the flow and the morphology of the reservoir. The main objective of the study is to determine the diversity and distribution of Mefou Lake phytoplankton in order to propose eutrophication control methods for sustainable water management. The specific objectives of the study are to characterize phytoplankton and determine the overall trophic level of the lake.

2. Materials and Methods

2.1. General characteristics of study site

Mefou Lake locates between the villages Minkoameyos, Etoud and Ozom 1. It is located between 3° 52' to 3° 58' N and 11° 22' to 11° 29' E. The upper watershed has an area of 69 Km^2. It is oriented generally NO-SE. It crosses an alluvial plain while describing numerous meanders. The presence of a few outcrops of granite and eruptive rocks is noted on the shores of the lake [12, 13]. Weather conditions, the climate of the upper Mefou watershed is identical to that of Yaounde. It is an equatorial climate with four seasons of unequal importance. It is punctuated by two rainy seasons (March - June and September - November) that alternate with two dry seasons (July - August and December - February) [12]. This climate is also characterized by abundant rainfall (1650 mm/year), an average temperature of 24.2 °C and a thermal amplitude of 32.8 °C. The hygrometry is very high and has an annual average of 80%. It varies between 35% and 60% in the day following the seasons and reaches 98% in the evening [10].

2.2. Period and study station

Sampling took place monthly from May 02, 2017 to May 24, 2018 in 7 study stations. These stations were defined according to the mouths of the rivers supplying the lake and the position of the retaining dam (Fig. 1). Stations 1 (Minkoa 1), 2 (Etoude 1), 3 (Etoud 2), 4 (Ozom), 5 (Minkoa 2) are located at river mouths from Minkoameyos, Etoud and Ozom villages. Station 6 (Middle) is located in the middle of the retaining lake and Station 7 (Dam) is located at the retaining dam, downstream of the lake.

2.3. Sampling, identification and enumeration of phytoplankton

Sampling was carried out at the same depth levels (at the surface and about 100 cm deep). The qualitative aspect of phytoplankton was determined from samples taken by horizontal lines, using a plankton net of 40 µm of diameter. After harvesting, the samples were immediately fixed by addition of formaldehyde to 5% of the volume. Sub-samples underwent frustule cleaning treatment by roasting and rinsing, then mounted between slides and coverslip for diatom identification. For the establishment of the inventory of the various taxa harvested, specialized determination keys were used: [14, 15, 16, 17, 18, 19, 20, 21].

For the quantitative study, samples were taken from the surface by a 5 L bucket and 100 cm deep by an integrating pipe. After formalin fixation at 5% volume immediately, the samples were concentrated according to the sedimentation process, long durations, bottling and siphoning of the supernatant. 1 ml subsamples were counted by the Malassez's slide under ordinary light microscopy.

2.4. Descriptive and synthetic elements

Specific richness

The species richness (S) is defined by the total number of taxa identified in a sample. It is an element that indicates the specific variety of the stand. Species richness may well be a distinctive criterion of the ecosystems or stations studied within a given ecosystem.

Diversity index

The introduction by ecologists of the concept of species diversity was intended to account for the unequal distribution of individuals among species. Among the indices established for the estimation of this diversity, the Shannon index (H') remains the most used, it has an indisputable superiority over the others. The Shannon index represents a wealth of information on the stand structure of a given sample and how individuals are distributed among different species. A low diversity index indicates that the community is young with dominance of one or a small number of species, whereas a high index characterizes mature populations with a complex specific composition. The Shannon diversity index (H') relative to a sample corresponds to the value in bits calculated from the formula: $H' = -\sum_{i=1}^{s}((ni/N) \times \log2\ (ni/N))$, with H' = Shannon diversity index, ni = number of individuals belonging to a species, N = total number of species.

Microalgal density

The calculation of the density (D) is expressed by the formula [1]: D = Ni×R×1000/v, with D = density in number of cells per milliliter (Cell/ml), R = ratio between the surface of the cell counting and ocular field area), 1000 = conversion factor in liters and v = sedimented sample volume in ml.

2.5. Statistical analysis

The multiple comparison of the groups was carried out by the ANOVA one-way parametric test and Student's T-test using the Past 3.02a software. The differences were considered significant for $p < 0.05$. Correspondence Factor Analysis (CFA) was applied to stand composition to group sampling sites according to their floristic similarities. These analyzes were performed with the XLSTAT 2014 software and Past2.02a for the dendrograms.

3. Results

3.1. Specific richness

Global phytoplankton composition Microscopic analysis of the samples collected, both at the surface and at the depth, made it possible to establish a floristic list of 79 taxa. These 79 taxa, listed belong to 12 systematic classes. Cyanophyceae dominate the phytoplankton of Mefou Lake. They constitute more than 29.87% of the total species richness (Table 1). The class Bacillariophyceae is also a large part of this taxonomic richness (18.18%). Of less importance, appear Pyramimonadophyceae and Ulvophyceae with specific wealth of 01.29% of the total.

3.2. Diversity by station over time at the surface and at depth

The diversity index is variable in surface between the stations of 4.14 bits (Etoud 1) to 2.25 bits (Etoud 2). In depth, it varies from 3.72 bits (Etoud 1) to 2.43 bits (Etoud 2) (Fig. 2). In general, the diversity index is higher in surface than in depth.

The monthly variation of Shannon-Weaver's index presents two areas (Fig. 3). The first zone is marked by high index values, during the two dry seasons of the study zone (July-August and december-February) ; the second zone is marked by low values of the index without significant diffrences, during the two rainy seasons (september-October and March-June). The highest value is obtained in January 2018 at the minkoa 1 station of 4.14 bits. The lowest value is obtained at the etoud 2 station from November 2017 to December 2017 of 2.4 bits.

3.3. Evolution of total densities

The monthly variation in density follows the same sequence as the Shannon diversity index (Fig. 4). It is most important between July-August and February-March. Cyanophyceae remainthe most dense during all months with the maximum obtained in February of 44 ± 10 Cell/ml. It is followed by Bacillariophyceae whose maximum value is obtained in February of 25 ± 05 Cell/ml. Chlorophyceae and Euglenophyceae also appear mainly during all months.

In general, the cell density in the stations is variable (Fig. 5). The Cyanophyceae class appears to be the most dense. It ranges from 53.6×10^3 Cell/ml (Cyanophyceae) in the Middle to 0.7×10^3 Cell/ml (Mediophyceae) to Minkoa 1.

3.4. Spatial variation of species by station

Factorial correspondence analysis shows that factorial axes F1 and F2 bring stations closer to species (Fig. 5). Station Etoud 2 is group I. It is characterized by the following exclusive species: *Cyclotella meneghiniana*, *Trachelomonas leifevrei*, *Caelastrum kuetzingianum*, *Merismopedia aquatilis* and *Synechocystis aquatilis*. The dam station is group II. It is characterized by the following exclusive species: *Achnanthidium* sp., *Botryococcus* sp., *Chlorogonium* sp., *Cylindrocapsa* sp., *Diatoma mesodon*, *Nitzschia fonticola*, *Nostoc flosaquae*, *Nostoc* sp., *Phacus* sp., *Rhodomonas* sp., *Scenedesmus acutus*, *Sphanocystis* sp., *Stenopterobia* sp., *Stephanodiscus hantzschii*, *Stephanodiscus minutulus* and *Synechococcus aeruginosus*. The Etoud 1, Minkoa 1, Middle, Minkoa 2 and Ozom stations are group III. They are characterized by the following common species: *Actinastrum hantzschii*, *Ankistrodesmus gracilis*, *Aphanizomenon flosaquae*, *Aphanocapsa holsatica*, *Aphanocapsa littoralis*, *Aphanocapsa* sp., *Aulacoseira granulata*, *Caloneis bacillum*, *Caloneis placentula*, *Calothrix scopulorum*, *Chlamydomonas* sp., *Cocconeis placentula*, *Coelospharium kuetzingianum*, *Colacium cyclopicola*, *Coscinodiscus ehrenbergii*, *Cryptomonas* sp., *Cyclotella gamma*, *Cymbella turgida*, *Diatomella* sp., *Enteromorpha flexuosa*, *Euglena* sp., *Euglena spirogyra*, *Euglena viridis*, *Eutreptiella gymnastica*, *Gomphonema acuminatum*, *Gonium* sp., *Haematococcus* sp., *Lepocynclis* sp., *Microcoleus lacustris*, *Microcystis littoralis*, *Navicula cryptocephala*, *Nostoc entophyllum*, *Nostoc palludosum*, *Oedogonium* sp., *Arthrospira platensis*, *Planktothrix rubescens*, *Oscillatoria* sp., *Jaaginema subtilissima*, *Parvodinium pusillum*, *Phacotus lenticularis*, *Phacotus* sp., *Phacus orbicularis*, *Phacus tortus*, *Rhopalodia*, *Pleurotaenium* sp., *Prorocentrum micans*, *Prorocentrum rostratum*, *Pyramimonas cuneata*, *Rivularia aquatica*, *Rivularia* sp., *Staurastrum* sp., *Stigeoclonium aestivale*, *Synechocystis aquatilis* and *Thallassiosira pseudonana*.

3.5. Determination of trophic status

In the study, an indicator was used to assess the trophic level of water, transparency (Table 2). According to the criteria established by European Framework Directive, Mefou Lake, object of the study, presents a uniform eutrophic state.

4. Discussion

The species richness is important (79 taxa). For comparison, [22] inventoried in the Loire estuary twice as much of the specific richness determined in the site, ie 150 species. [1] has identified 118 species at Ta'abo Lake in Ivory Cost. The harvest was characterized by large size microalgae. These microalgae are mostly *Chlamydomonas* sp., *Eudorina elegans*, *Microcoleus lacustris* and *Aphanizomenon flos-aquae*. These results go in the same direction as those of [23] having characterized the municipal Lake of Yaoundé, they showed that the species of large sizes are the most representative of the lake with the genera *Chlamydomonas* and *Eudorina* [1]. sampled at Dam Ta'abo Lake showed that *Eudorina elegans* still appears in the samples for all sampling campaigns except October. According to [7], phytoplankton develop two months after the rainy season. In the same sense, they show that lake phytoplankton is dominated by Cyanophyceae. Communities dominated by phytoplankton are mainly associated with areas where vertical mixing brings nutrients to the superficial oceanic layer. These communities mostly use nitrates and are involved in primary production [24, 25]. The mix, temperature and availability of light and nutrients fluctuate over different time scales and can influence phytoplankton dynamics. The high phytoplankton densities characteristic of the upstream sector are in good agreement with the large quantities of particulate organic matter developed precisely by the autotrophy of phytoplankton [7, 26, 27]. For its growth and reproduction, phytoplankton needs light energy and nutrients. In this sense [28], shows that the vertical mixing of the water column influences the dynamics of phytoplankton populations: turbulence stimulates the growth of Diatomophyceae, Dinophyceae developing, conversely, when the water column is stratified. The results obtained oppose them because the Dinophyceae appear last with a proportion of 3.5%. On the other hand, these results are in line with those of [29] who showed that the main difference between phytoplankton diversity in freshwater and in the marine environment, considering only planktonic organisms, lies in the representation level. Different classes Chrysophyceae and Euglenophyceae are much better represented in freshwater, Dinophyceae are more frequent in the marine environment.

The distribution of the stations according to the species according to the factorial analysis of the correspondences shows that the stations Minkoa 1, Minkoa 2, Etoud 1, Ozom and Middle are close. This could reflect similarities for these stations in terms of pollutant input or elements of mineralization of water. The production of drinking water fears oils, gasoline and exhaust gases produced by motorized canoes as well as bacterial pollution caused by organic inputs or even trophic dysfunctions linked to certain fishing practices (use of the products toxic) [1, 30]. Global changes, including global warming, can have a significant impact on phytoplankton communities. These global pressures are combined with local pressures generated by anthropogenic activities that occur at the scale of each ecosystem [31, 32]. In the same direction [7, 33] have shown in their work that turbulence and the action of grazers can alter the evolution of a population by causing numerical increases or decreases even in the short term.

The seasonal variations in the algal density in Lake Mefou are not very comparable depending on the study stations due to the disparity in size of the organisms for different specific compositions. These results corroborate with those of [30]. He also showed that the levels of pigments in the cells are relatively low during periods of stability, and increase when the water in mixed. According to [33], the growth of phytoplankton is stimulated by an increase in solar radiation in the dry season. These results being comparable to those obtained, explain the high densities recorded in small and large dry seasons.

[30] on the contrary, suggest that the rise in temperature can only play a minor role. Algae growth in the spring was obtained by increasing insolation without a significant increase in temperature or nutrient concentrations.

The minimum density values obtained in November are related to the strong development of zooplankton which consumes large forms (*Microcystis* and *Eudorina*). These results are contrary to those obtained by [30] who have shown that the cumulative action of high temperatures and strong sunshine responsible for a drop in the pigments in the cells resulting in the decrease in phytoplankton density.

After the long rainy season, a change in the succession of phytoplnakton is observed, in reponse to change in the status of nutrients: the development of green alga Coelastrum and other Chlorococcales (*Phacotus*), and the appearance of blue-green algae (Aphanizomenon). The increase in Chlorococcales growth is favored by the strong sunstroke in this period may be an indication of the eutrophication of the environment.

At the end of the short rainy season, the slight increase in algal density may be linked to the redistribution of subsurface algae in surface waters [34].

During the long rainy season, phytoplankton decrease to their annual minimum. These results are in agreement with those of [35]. This decrease is due to the low temperatures, the low insolation and the high turbidity of the waters.

The development of Chlorococcales and a global appearance of blue-green algae (*Aphanizomenon*) in the waters of the epilimnion on the one hand, and on the other hand the deoxygenation of deep waters, can be interpreted as the first signs of a certain degradation of water quality [30]. These results corroborate with those obtained, since the algae *Aphanizomenon* were mainly found as dominant algae in depth.

Referring to the European Framework Directive standards, the ecological status of the sampled stations and the reservoir lake as a whole were classified based on the class boundaries proposed by [1] for the transparency. The results show that the waters of Mefou Lake are eutrophic and have poor ecological status. In Europe, the implementation of a water policy (the European Framework Directive or DCE, 2000/60/EC) to achieve a good ecological status for artificial water bodies by 2027 requires managers to define or adopt a certain strategy to ensure the ecological monitoring of the reservoirs and to provide some indices of state. Among the biological indices, phytoplankton is proposed by the DCE as a quality element for lakes. It is identified today as a potential bio-indicator since it responds to trophic changes in water bodies [1, 31]. Microalgae are sensitive to excessive supplies of inorganic material and can cause problems with eutrophication. Compared to animals, algal stands represent a very good tool for understanding biodiversity, the spatiotemporal dynamics and the functioning of hydrosystems. Indeed, because of their low longevity and high rate of multiplication, microalgae integrate a very short time step and allow an almost immediate seizure of natural ecological changes (or provoked) [36, 37].

Table 1: Total specific richness of microalgae.

Phyllum	Class	Order	Family	Nomber of species
Bacillariophyta	Bacillariophyceae	7	9	14
	Coscinodiscophyceae	2	2	3
	Mediophyceae	2	2	6
Charophyta	Conjugatophyceae	1	1	2
Chlorophyta	Chlorophyceae	3	8	11
	Pyramimonadophyceae	1	1	1
	Trebouxiophyceae	2	2	2
	Ulvophyceae	1	1	1
Cryptophyta	Cryptophyceae	2	2	2
Cyanobacteria	Cyanophyceae	3	9	23
Euglenozoa	Euglenophyceae	1	3	11
Miozoa	Dinophyceae	2	2	3

Table 2: Trophic state of Mefou Lake according to [1].

Indicator	Stations						
	Minkoa 1	Etoud 1	Etoud 2	Ozom	Minkoa 2	Milieu	Dam
Transparency (m)	0.35 ± 0.18a	0.35 ± 0.10a	0.40 ± 0.15a	0.37 ± 0.19a	0.41 ± 0.15a	0.36 ± 0.11a	0.35 ± 0.15a
Trophic state	Eutrophic						

There is no significant difference between culumns with the same letter (p<0.05).

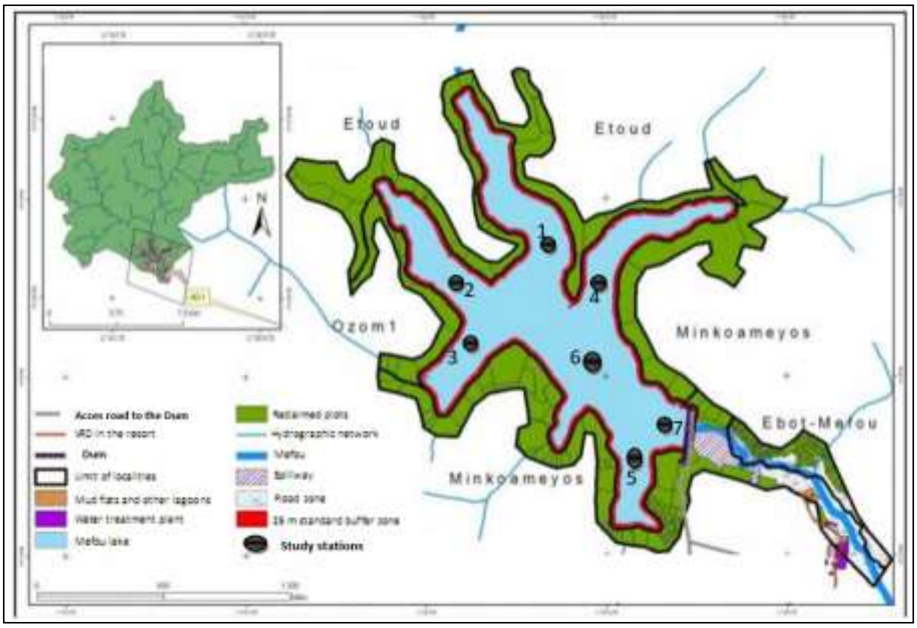

Fig 1: Map showing the different sampling stations on Mefou Lake [11].

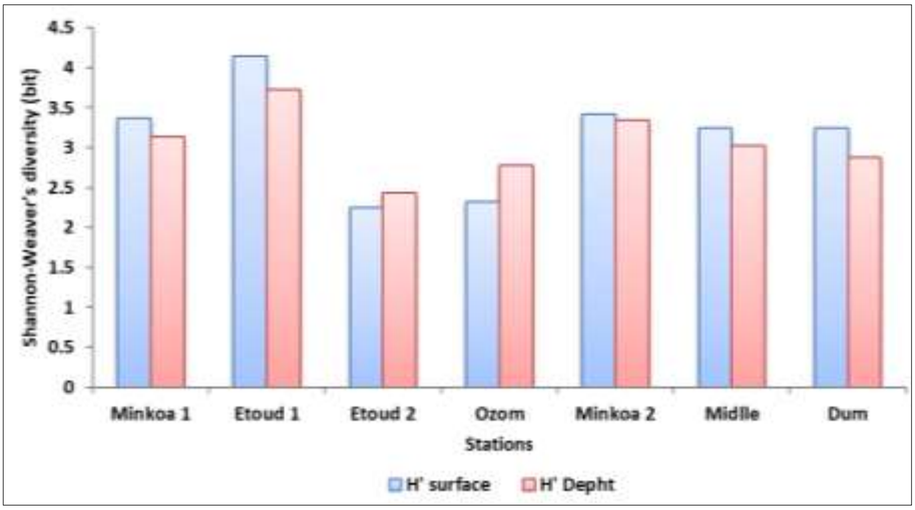

Fig 2: Variation of the diversity index according to the stations.

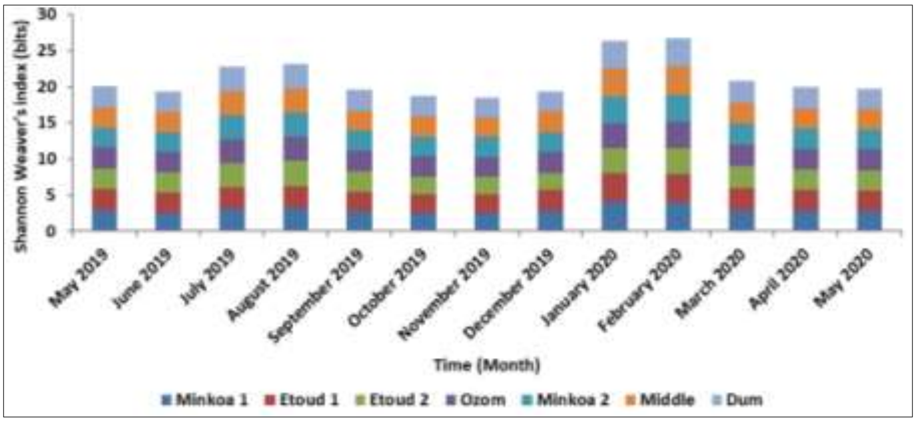

Fig 3: Monthly variation of Shannon-Weaver index depending on the stations.

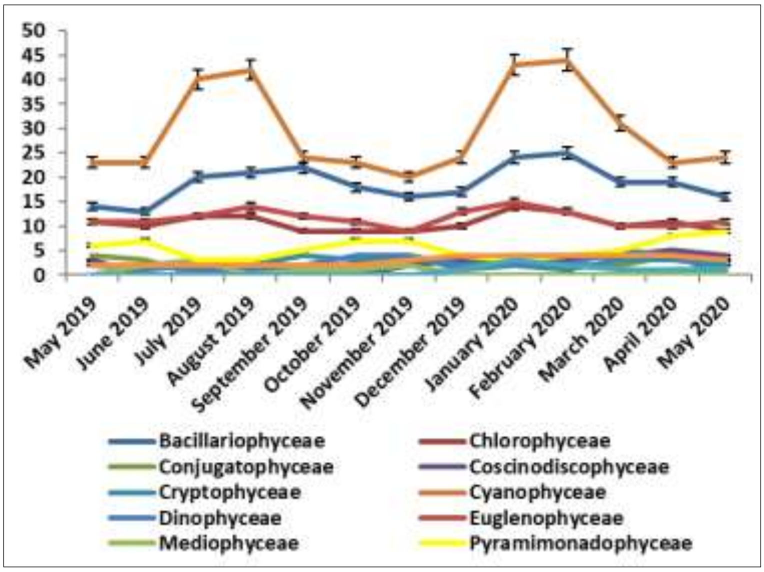

Fig 4: Monthly variation of density depending of algal classes on the study area.

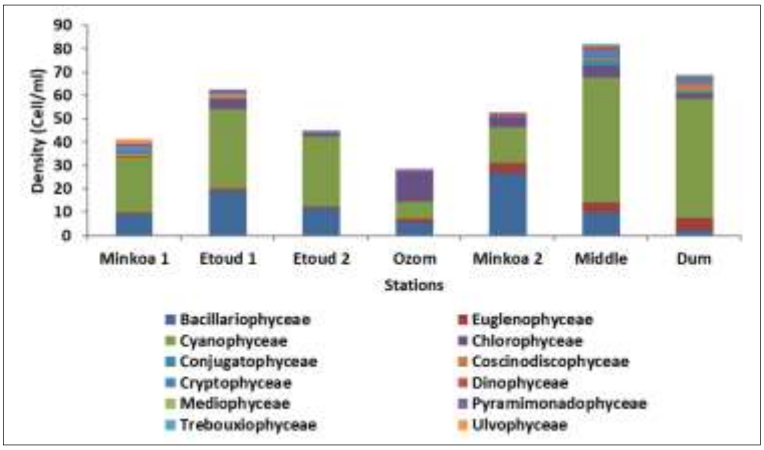

Fig 5: Total density of algae classes depending on the stations.

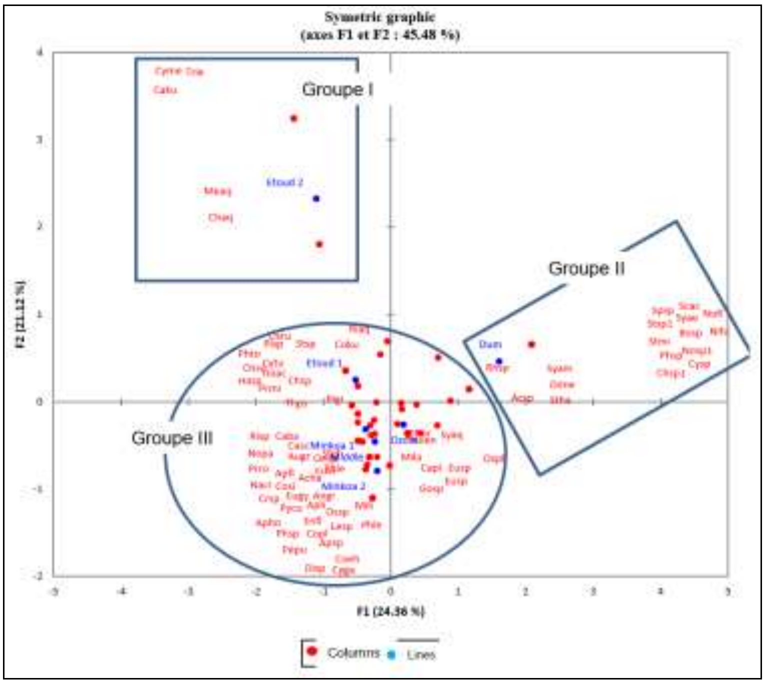

Fig 6: Spatial variation of species by station (*Achnantidium* sp. = Acsp, *Actinastrum hantzschii* Lagerheim = Acha, *Aphanizomenon flosaquae* Ralfs ex Bornet & Flahault = Apfl, *Aphanocapsa holsatica* (Lemmermann) G. Cronberg & Komárek = Apho, *Aphanocapsa littoralis* Hansgirg = Apli, *Aphanocapsa* sp. = Apsp, *Arthrospira platensis* Gomont = Arpl, *Aulacoseira granulata* (Ehrenberg) Simonsen = Augr, *Botryococcus* sp. = Bosp, *Caloneis bacillum* (Grunow) Cleve = Caba, *Caloneis placentula* Ehrenberg = Capl, *Calothrix scopulorum* C. Agardh ex Bornet & Flahault = Casc, *Chlamydomonas* sp. = Chsp, *Chlorogonium* sp. = Chsp, *Cocconeis placentula* Ehrenberg = Copl,

Coelosphaerium kuetzingianum Nägeli = Coku, *Colacium cyclopicola* (J. Gicklhorn) Woronichin & Popova = Cocy, *Coscinodiscus lineatus* Ehrenberg = Cosli, *Cryptomonas* sp. = Crsp, *Cyclotella gamma* Sovereign = Cyga, *Cyclotella meneghiniana* Kützing = Cyme, *Cylindrocapsa* sp. = Cysp, *Diatomella* sp. = Disp, *Encyonema elginense* (Krammer) D.G. Mann = Enel, *Euglena* sp. = Eusp, *Euglena viridis* (O.F. Müller) Ehrenberg = Euvi, *Eutreptiella gymnastica* Throndsen = Eugy, *Gomphonema acuminatum* Ehrenberg = Goac, *Gonium* sp. = Gosp, *Haematococcus* sp. = Hasp, *Jaaginema subtilissimum* (Kützing ex Forti) Anagnostidis & Komárek Jasu, *Lepocinclis* sp. = Lesp, *Lepocinclis spirogyroides* B. Marin & Melkonian = Lesp, *Messastrum gracile* (Reinsch) T.S. Garcia = Megr, *Microcoleus lacustris* Farlow ex Gomont = Mila, *Microsystis aeruginosa* (Kützing) Kützing = Miae, *Navicula cryptocephala* Kützing = Nacr, *Nitzschia fonticola* (Grunow) Grunow = Nifo, *Nostoc entophytum* Bornet & Flahault = Noen, *Nostoc paludosum* Kützing ex Bornet & Flahault = Nopa, *Nostoc* sp. = Nosp, *Odontidium mesodon* (Kützing) Kützing = Odme, *Oedogonium* sp. = Oesp, *Oscillatoria* sp. = Ossp, *Parvodinium pusillum* (Penard) Carty = Papu, *Phacotus lenticularis* (Ehrenberg) Diesing = Phle, *Phacotus* sp. = Phsp, *Phacus orbicularis* K. Hübner = Phor, *Phacus* sp. = Phsp, *Phacus tortus* (Lemmermann) Skvortzov = Phto, *Planktothrix rubescens* (De Candolle ex Gomont) Anagnostidis & Komárek = Plru, *Pleurotaenium* sp. = Plsp, *Prorocentrum micans* Ehrenberg = Prmi, *Prorocentrum rostratum* F. Stein = Prro, *Pyramimonas cuneata* W. Conrad & H. Kufferath = Pycu, *Rhodomonas* sp. = Rhsp, *Rhopalodia gibba* (Ehrenberg) Otto Müller = Rhgi, *Rivularia aquatica* De Wildeman = Riaq, *Rivularia* sp. = Risp, *Staurastrum* sp. = Stsp, *Stenopterobia* sp. = Stsp, *Stephanodiscus hantzschii* Grunow = Stha, *Stephanodiscus minutulus* (Kützing) Cleve & Möller = Stmi, *Stigeoclonium aestivale Hazen* = Stae, *Synechococcus aeruginosus* Bourrelly = Syar, *Synechocystis aquatilis* Sauvageau = Syaq, *Tetradesmus obliquus* (Turpin) M.J. Wynne = Teob, *Thalassiosira pseudonana* Hasle & Heimdal = Thps, *Trachelomonas lefevrei* Deflandre = Trle, *Ulva flexuosa* Wulfen = Ulfl.

6. Conclusions

The main objective of the study was to determine the diversity and distribution of Mefou Lake phytoplankton in order to propose eutrophication control methods for sustainable water management. Floristic richness is high of 79 taxa. These 79 taxa are divided to 12 systematic classes. Cyanophyceae dominate the phytoplankton of Mefou Lake. They constitute more than 29.87% of the total species richness. The diversity index is variable in surface between the stations of 4.14 bits (Etoud 1) to 2.25 bits (Etoud 2). The monthly variation in density is most important between July-August and February-March. Cyanophyceae remainthe most dense during all months with the maximum obtained in February of 44 ± 10 Cell/ml. According to the criteria established by European Framework Directive, Mefou Lake, presents a uniform eutrophic state. These species could be used as indicators of pollution in the framework of environmental planning for a better follow-up of the quality of waters of this region. This study also contributes to the knowledge of algal biodiversity in Africa, in particular Cameroon.

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