

## Original Article

# Composition and seasonal variation of phytoplankton community in Lake Hlan, Republic of Bénin

Arsène Mathieu Houssou<sup>\*</sup>,<sup>1,2</sup>, Hyppolite Agadjihouédé<sup>1,2</sup>, Clément A. Bonou<sup>3</sup>, Elie Montchowui<sup>1,2</sup>

<sup>1</sup>Laboratory of Hydrobiology and Aquaculture, Faculty of Agricultural Sciences, University of Abomey-Calavi, Republic of Bénin.

<sup>2</sup>Laboratory of Research in Aquaculture and Aquatics Biology and Ecology, School of Aquaculture of Vallée, National University of Agriculture, Republic of Bénin.

<sup>3</sup>Research Laboratory in Applied Biology, Polytechnic School of Abomey-Calavi, University of Abomey-Calavi, Republic of Bénin.

**Abstract:** Knowledge of biodiversity of aquatic ecosystems is nowadays a challenge for global research. Phytoplankton being very important in the sustainability of ecosystems, its mastery allows the development of early monitoring and evaluation tools of the health status of aquatic environments. The study aims to make an initial inventory of phytoplankton of the lake Hlan and to evaluate the influence of hydrologic season on its dynamics. Plankton samples were collected monthly between May and December 2012 using plankton net of 30 µm size. They were then treated and species identified using light microscopy. 39 species in 7 classes (Bacillariophyceae, 18 species in 10 genera), (Cyanophyceae, 5 species in 5 genera), (Chlorophyceae, 5 species in 3 genera), (Zygnematophyceae, 3 species in 2 genera), (Trebouxiophyceae, 2 species in 2 genera) (Euglenophyceae, 4 species in 3 genera) and (Dinophyceae, 2 species in 2 genera) have been identified. The Shannon index varied between 4.8 and 5.1 bit cell<sup>-1</sup>. This shows that the ecosystem is balanced. Nevertheless, the presence of potentially toxic species requires a monitoring program for Lake Hlan.

### Article history:

Received 12 September 2016

Accepted 7 December 2016

Available online 25 December 2016

### Keywords:

Cyanobacteria

Diatoms

Dinoflagellate

Hydrological season

Phytoplankton diversity

## Introduction

Highly diversified phytoplankton is the basis of food webs in aquatic ecosystems. Despite its importance, phytoplankton is very sensitive to environmental changes. Hence, environmental variations often cause major damage which may be irreversible on the phytoplankton population. The final consequence is the loss of diversity in aquatic impacted environments. That at the higher level could affect the well-being of human.

Due to its high sensitivity, phytoplankton is now considered effective ecosystem indicator. Therefore, it is widely used to assess or predict the state of aquatic ecosystems (Gao and Song, 2005; Barinova et al., 2005; Barinova et al., 2006; Barinova and Nevo, 2012; Madhu et al., 2007). Knowledge of biodiversity of inland water phytoplankton is therefore an essential basis for the use of this biological compartment for the purpose of

ecosystems biomonitoring (Houssou et al., 2015). Hence, this study aims to be a first evaluation of phytoplankton of the lake Hlan in the south of Benin Republic.

Based on its location and topography, the Lake Hlan is roughly difficult to access. It is an isolated ecosystem with little direct human impact. Indirect inputs received may be drained by its tributaries (mainly Hlan River). So this is an interesting ecosystem with very little known biodiversity (only its ichthyofauna was assessed (Montchowui et al., 2008). No data exist on its phytoplankton diversity. The purpose of this study is to provide the first data on the diversity of phytoplankton. Such information will provide the basis for further studies.

## Materials and Methods

**Study area and sampling site:** The lake Hlan is localized at Toffo town in the south of Benin

\* Corresponding author: Arsène Mathieu Houssou  
E-mail address: arsnehous@yahoo.fr

Republic. It is a widening of the Hlan River at Kpomè (6°56.88'N, 2°19.48'E). Its area covers 165 ha. In the flood times, its water is influenced by that of the rivers Samion, Da, Hoho and Hlan. Those rivers flow into the lake starting from the swamp of Adogbé and Hon village. Two other great rivers influences the Lake at the flood time. It is about Zou and Ouémé rivers through respectively Zounga and Agbagbé tributary.

Three stations with different levels of anthropogenic activities and composed different habitats were chosen as representative of the water map for sampling plankton (Fig. 1). So from upstream to downstream, the sampling stations were: Houvenou (06°57'49.6" N, 002°19'04.4" E, 53 m), Awayamey (06°56'29.2" N, 02°19'57.4" E, 25 m) and Dezinmey (06°55'57.3"N, 02°20'17.3"E, 35 m).

**Phytoplankton sampling and analysis:** Monthly phytoplankton sampling was performed from May to December 2012. Sampling was done according to the hydrological seasons of Benin Republic. The period from August to November represented the flood time while May to July represented the recession period. The December samples are used to see the changes just after the flood. Samples were collected using plankton net of 30 µm mesh. Vertical sampling procedure (full depth) was used at three different points of each station. A composite sample resulting from the mixture of the three sub-samples is immediately preserved with formaldehyde 5%. It is then transported to lab and stored in darkness condition for future analysis. The recorded environmental parameters are presented in Table 1.

Samples were settled and precipitated to a final same volume of 100 ml. Species were identified under a light microscope (Olympus B102). The species determination was based on Prescott (1954), Compère (1974, 1975), Vanlandingham (1982), Nogueira and Correia (2000), Tsukii (2005), Kinross (2007), Bellinger and Sigeo (2010), and Oyadomari (2011). Counting of cells/colonies of different species identified was done with a hemacytometer (Burker Turk four grids). Four hundred (400) cells/colonies were counted for each species. High

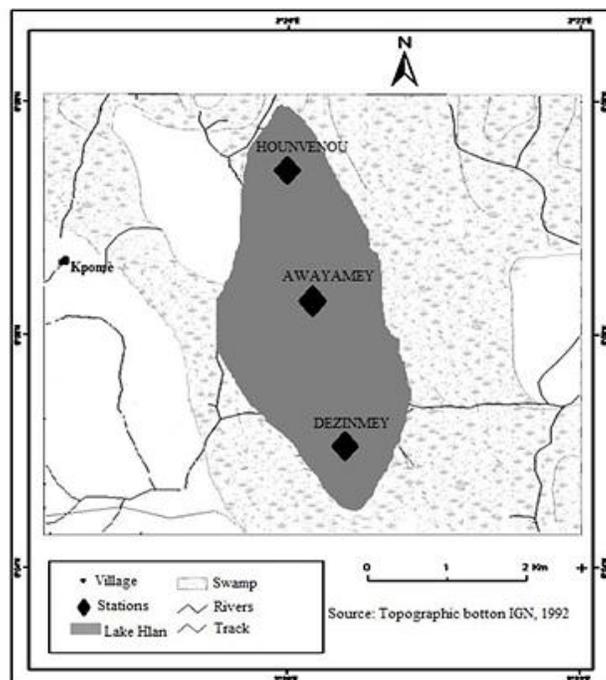


Figure 1. Geographical map of Lake Hlan.

abundant species which density per milliliter of sample was greater than 400 were counted in three consecutive 1 ml aliquots (regularity is then searched). The very rare species have been counted throughout the sample volume (milliliter per milliliter). The abundance of each species was calculated using the following formula:

$$D = \frac{1}{2} \left( \frac{N}{Td} * 100 \right)$$

Where D is the density per liter of the species, N is the number of cells/colonies counted and Td is the sample rate corresponding to N.

**Data analysis:** All biological data were transformed by using Log (x+1) according to Frontier (1973). The Principal Component Analysis (PCA) and the Cluster Analysis were used to discriminate the typology of species distribution. The monthly variations of phytoplankton abundance was studied with the ANOVA test, followed by the LSD of Fisher post-hoc test. PCA and one way ANOVA tests were performed in Statistica v7, while the cluster analysis was done with PAST program. The biological diversity was also study using the Shannon diversity index, calculated by:

$$H' = - \sum \left[ \left( \frac{n_i}{N_i} \right) * \log_2 \left( \frac{n_i}{N_i} \right) \right]$$

Table 1. Monthly variation of abiotic factor in Hlan Lake during the study.

	May	June	July	August	September	October	November	December
Temperature	29.8±0.1 <sup>a</sup>	27.8±0.8 <sup>b</sup>	27.3±0.5 <sup>c</sup>	27.2±0.3 <sup>d</sup>	27.4±0.2 <sup>e</sup>	28.1±0.2 <sup>f</sup>	28.1±0.4 <sup>g</sup>	28.6±0.01 <sup>h</sup>
Dissolved Oxygen (mg.l <sup>-1</sup> )	5.0±0.9 <sup>a</sup>	4.5±0.4 <sup>b</sup>	4.2±0.8 <sup>c</sup>	3.5±0.2 <sup>d</sup>	4.0±0.3 <sup>e</sup>	4.3±0.2 <sup>f</sup>	4.2 ±0.1 <sup>g</sup>	4.6±0.5 <sup>h</sup>
pH	6.9±0.1 <sup>a</sup>	6.8±0.2 <sup>b</sup>	6.8±0.1 <sup>c</sup>	6.3±0.2 <sup>d</sup>	6.4±0.3 <sup>e</sup>	6.9±0.2 <sup>f</sup>	6.8±0.4 <sup>g</sup>	7.0±0.2 <sup>h</sup>
TDS (ppm)	37.2±4.2 <sup>a</sup>	39.8±1.9 <sup>b</sup>	48.5±4.5 <sup>abc</sup>	42.2±3.3 <sup>cd</sup>	45.0±2.7 <sup>ae</sup>	36.2±3.1 <sup>cdef</sup>	42.3±0.8 <sup>cfg</sup>	46.3±1.9 <sup>abfh</sup>
Conductivity (µS.cm <sup>-1</sup> )	71.7±6.7 <sup>a</sup>	83.2±11.6 <sup>b</sup>	92.5±6.8 <sup>ac</sup>	82.0±6.0 <sup>d</sup>	87.0±5.5 <sup>ae</sup>	72.5±6.0 <sup>cef</sup>	82.2±2.3 <sup>g</sup>	90.2±3.4 <sup>afh</sup>
Transparency (cm)	95.7±25.4 <sup>a</sup>	76.0±5.3 <sup>b</sup>	67.0±33.8 <sup>c</sup>	65.0±5.0 <sup>d</sup>	76.0±1.7 <sup>e</sup>	64.0±32.3 <sup>f</sup>	81.0±13.9 <sup>g</sup>	93.5±14.3 <sup>h</sup>
Depth (m)	2.4±0.4 <sup>a</sup>	2.6±0.2 <sup>b</sup>	3.0±0.4 <sup>c</sup>	3.9±0.5 <sup>d</sup>	5.9±1.3 <sup>abcde</sup>	4.3±0.4 <sup>af</sup>	3.5±0.8 <sup>g</sup>	2.8±0.3 <sup>eh</sup>

The values of the same line with common letter as power are significantly different One way ANOVA, Post-hoc: LSD of Fisher,  $P < 0.05$ .

Where H' is the index of diversity expressed in bit/individual, ni the number of the species, N the total number of individual constituting all the species, log<sub>2</sub> the logarithm on base 2.

## Results

**Seasonal spread of phytoplankton species:** A total of 39 species of phytoplankton were recorded during the study belonging to 7 classes (Table 2). The Bacillariophyceae was represented by 18 species in 8 genera. Chlorophyceae was composed of 5 species in 3 genera, while Zygnematophyceae and Trebouxiophyceae were represented by 3 species in 2 genera and 2 species in 2 genera, respectively. Cyanophyceae was composed of 5 species in 5 genera. Euglenophyceae and Dinophyceae were respectively composed of 4 species in 3 genera and 2 species in 2 genera.

During low water season, all species were identified, while *Urosolenia eriensis*, *Peridiniopsis quadridens*, *Stigeoclonium aestivale*, *Rhizosolenia setigera*, *Navicula* sp., *Urosolenia* sp., *Closterium parvulum* and *Coelastrum* sp. had disappeared with the increase in the water depth. The relative abundance showed absence of net dominant species. However, *Aulacoseira* sp., *Nitzschia sigma*, *Synedra acus*, *S. splendens*, *Closterium* sp. and *Closteriopsis* sp. are most abundant species.

**Phytoplankton abundance in relation with diversity index:** The total phytoplankton abundance and the Shannon diversity index variations throughout the study period are showed on Figure 2. Phytoplankton abundance had same profile with the diversity index.

The high diversity and abundance was observed during low water season. The observed phytoplankton community had a very good diversity index, ranged between 4.8 bit cell<sup>-1</sup> and 5.1 bit cell<sup>-1</sup>. Significant variation was observed both in total phytoplankton abundance and the diversity index seasonality.

**Typology of phytoplankton community:** Principal Components Analysis (PCA) of phytoplankton species is presented in the factorial design (1 and 2) on Figure 3. The cumulated eigenvalues was 75.25% and 13.95% respectively for first and second axis. The first axis was composed by both low water and flood seasons (May and August to December), while the second axis particularly and positively selected the month of July (first coming of flood waters). The first axis selected negatively both of two hydrologic seasons. The species as *Melosira* sp., *Nitzschia sigma*, *S. acus*, *S. splendens*, *Closterium* sp. and *Closteriopsis* sp. were not affected by hydrological season, while *Gomphonema vibrio*, *R. setigera*, *U. eriensis*, *Urosolenia* sp., *C. parvulum*, *Stigeoclonium* sp., *S. aestivale* and *Coelastrum* sp. were affected the flood. As to the month of July, *Gomphonema* sp. highly correlated is opposed to *G. ventricosum* and *Stigeoclonium* sp. In general, principal component analysis showed two groups of species. One is composed by species not affected by seasons and the second is affected by the flood event. These two groups of species are also showed on the cluster analysis (Fig. 4).

**Relationship between total phytoplankton and environmental parameters:** The linear relationship

Table 2. Distribution of phytoplankton species according to hydrologic seasons; the values in square bracket are the percentage of dominance (%).

Phytoplankton species	Hydrodynamic			
	Code	Low depth	Flood	After flood
<b>BACILLARIOPHYCEAE</b>				
<i>Aulacoseira granulata</i> Simonsen, 1979	D1	+ (2.7)	+ (2.6)	+ (3.3)
<i>Aulacoseira</i> sp. Thwaites, 1848	D2	+ (4.8)	+ (5.9)	+ (5.9)
<i>Bacillaria paxillifera</i> , Marsson, 1901	D3	+ (3.1)	+ (2.9)	+ (2.8)
<i>Nitzschia reversa</i> Smith, 1853	D4	+ (3.7)	+ (3.7)	+ (3.3)
<i>Nitzschia sigma</i> Smith, 1853	D5	+ (4.3)	+ (5.3)	+ (5.3)
<i>Synedra acus</i> Heurck, 1885	D6	+ (4.0)	+ (4.7)	+ (4.8)
<i>Synedra splendens</i> Kützing, 1844	D7	+ (4.0)	+ (4.6)	+ (4.5)
<i>Synedra</i> sp. Ehrenberg, 1830	D8	+ (3.2)	+ (3.8)	+ (3.7)
<i>Diatoma tenuis</i> Agardh, 1812	D9	+ (3.4)	+ (4.1)	+ (4.1)
<i>Gomphonema ventricosum</i> Gregory, 1856	D10	+ (1.0)	+ (1.0)	+ (2.2)
<i>Gomphonema vibrio</i> Ehrenb, 1843	D11	+ (0.8)	+ (0.3)	+ (1.1)
<i>Gomphonema</i> sp. Ehrenberg, 1832	D12	+ (1.1)	+ (1.1)	+ (1.0)
<i>Navicula</i> sp. Bory 1822	D13	+ (2.7)	+ (0.9)	-
<i>Surirella</i> sp. Turpin, 1828	D14	+ (3.0)	+ (3.3)	+ (3.5)
<i>Surirella capronii</i> Kitton, 1869	D15	+ (3.5)	+ (3.2)	+ (4.1)
<i>Rhizosolenia setigera</i> Brightwell, 1858	D16	+ (1.5)	+ (0.2)	-
<i>Urosolenia eriensis</i> .Smith, 1872	D17	+ (0.4)	-	-
<i>Urosolenia</i> sp. Round & Crawford, 1990	D18	+ (1.8)	+ (0.7)	-
<b>CYANOPHYCEAE</b>				
<i>Spirulina</i> sp. Turpin, 1892	CY1	+ (2.0)	+ (1.0)	+ (1.1)
<i>Oscillatoria</i> sp. Vaucher, 1893	CY2	+ (3.5)	+ (3.8)	+ (4.1)
<i>Raphidiopsis curvata</i> Fritsch and Rich, 1929	CY3	+ (2.6)	+ (3.0)	+ (3.2)
<i>Microcystis flos-aquae</i> Kirchner, 1898	CY4	+ (3.0)	+ (3.8)	+ (3.6)
<i>Stigonema</i> sp. Agardh, 1886	CY5	+ (2.7)	+ (3.2)	+ (3.3)
<b>CHLOROPHYCEAE</b>				
<i>Tetraedron incus</i> Smith, 1926	CH1	+ (2.6)	+ (2.4)	+ (2.6)
<i>Tetraedron</i> sp. Kützing, 1845	CH2	+ (2.3)	+ (2.3)	+ (2.5)
<i>Stigeoclonium</i> sp. Kützing, 1843	CH3	+ (0.2)	+ (1.0)	+ (1.9)
<i>Stigeoclonium aestivale</i> Collins, 1909	CH4	+ (1.9)	-	-
<i>Coelastrum</i> sp. Nageli, 1849	CH5	+ (1.2)	+ (1.0)	-
<b>ZYGNEMATOPHYCEAE</b>				
<i>Closterium parvulum</i> Nägeli, 1849	ZY1	+ (0.5)	+ (0.9)	-
<i>Closterium</i> sp. Nitzsch, 1848	ZY2	+ (3.9)	+ (4.0)	+ (4.9)
<i>Gonatozygon</i> sp. De Bary, 1858	ZY3	+ (3.5)	+ (3.5)	+ (3.2)
<b>TREBOUXIOPHYCEAE</b>				
<i>Actinastrum</i> sp. Lagerheim, 1882	TR1	+ (1.3)	+ (0.9)	+ (1.0)
<i>Closteriopsis</i> sp. Lemmermann, 1899	TR2	+ (3.8)	+ (4.5)	+ (4.5)
<b>EUGLENOPHYCEAE</b>				
<i>Strombomona</i> sp. Ehrenberg, 1835	E1	+ (2.8)	+ (2.8)	+ (2.9)
<i>Euglena</i> sp. Ehrenberg, 1830	E2	+ (3.4)	+ (3.9)	+ (3.2)
<i>Phacus longicauda</i> Dujardin, 1841	E3	+ (2.8)	+ (2.4)	+ (2.4)
<i>Phacus caudatus</i> Hübner, 1886	E4	+ (2.2)	+ (2.5)	+ (2.6)
<b>DINOPHYCEAE</b>				
<i>Peridiniopsis quadridens</i> Bourrelly, 1968	D1	+ (1.1)	-	-
<i>Peridinium bipes</i> Stein, 1883	D2	+ (3.6)	+ (4.3)	+ (3.4)

+ Present; - Absent; Numeric italic scores in bracket: relative abundance (%).

between the total phytoplankton abundance and environmental parameter with significant variation throughout the study period is presented on Figure 5. The Total Dissolved Solid (TDS) and conductivity

had low positive effect on the total phytoplankton abundance. The respective correlation coefficients are  $r=0.21$  and  $r=0.32$ . Regarding the water volume (Lake body depth), a negative impair is observed on

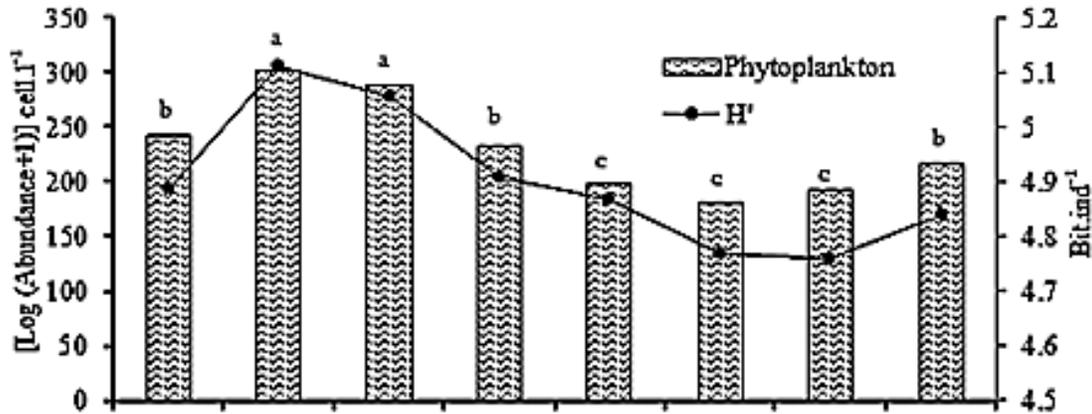


Figure 2. Compared variation of Shannon index (H') and total recorded phytoplankton abundance. Histogram with different letter are significantly different (One way ANOVA, LSD post-hoc of Fisher,  $P < 0.05$ ).

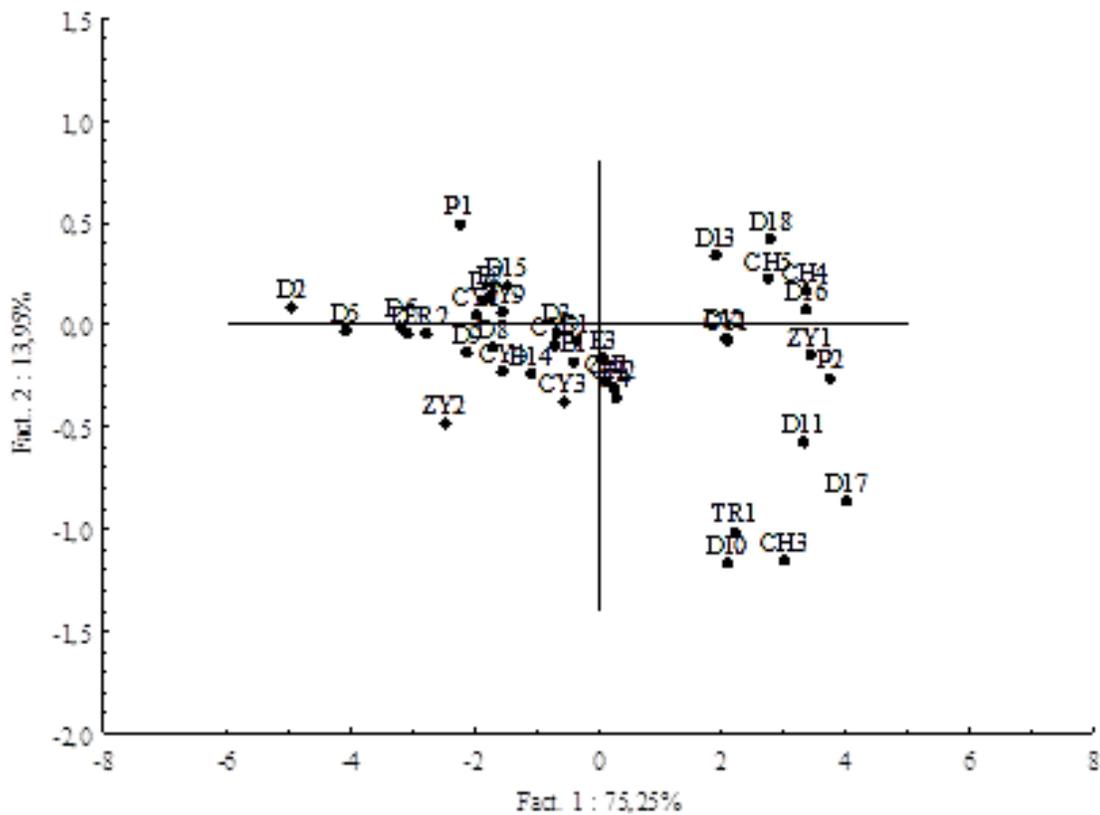


Figure 3. Principal component Analysis (PCA) of 39 recorded phytoplankton species.

the phytoplankton abundance ( $r = -0.59$ ).

**Discussion**

This study constituting the first inventory of phytoplankton species in the Hlan Lake. It shows in addition to those identified species their assigned behaviors vis-à-vis to the hydrological seasons. A total of 39 phytoplankton species were identified. The structure of the assembly appeared dominated

by diatoms species, showing a sufficient presence of mineralized organic matter (Maestrini and Robert, 1981; Bennouna et al., 2000; Kemka et al., 2004; Atanle et al., 2012, 2013; Houssou et al., 2015). This obtained structure also shows that the Lake Hlan has an apparent ecosystem health (Houssou *et al.*, 2016), diatomic species being potentially more sensitive to pollution. The Shannon diversity index ranging between 4.8 and 5.1 bit cell<sup>-1</sup> confirms the

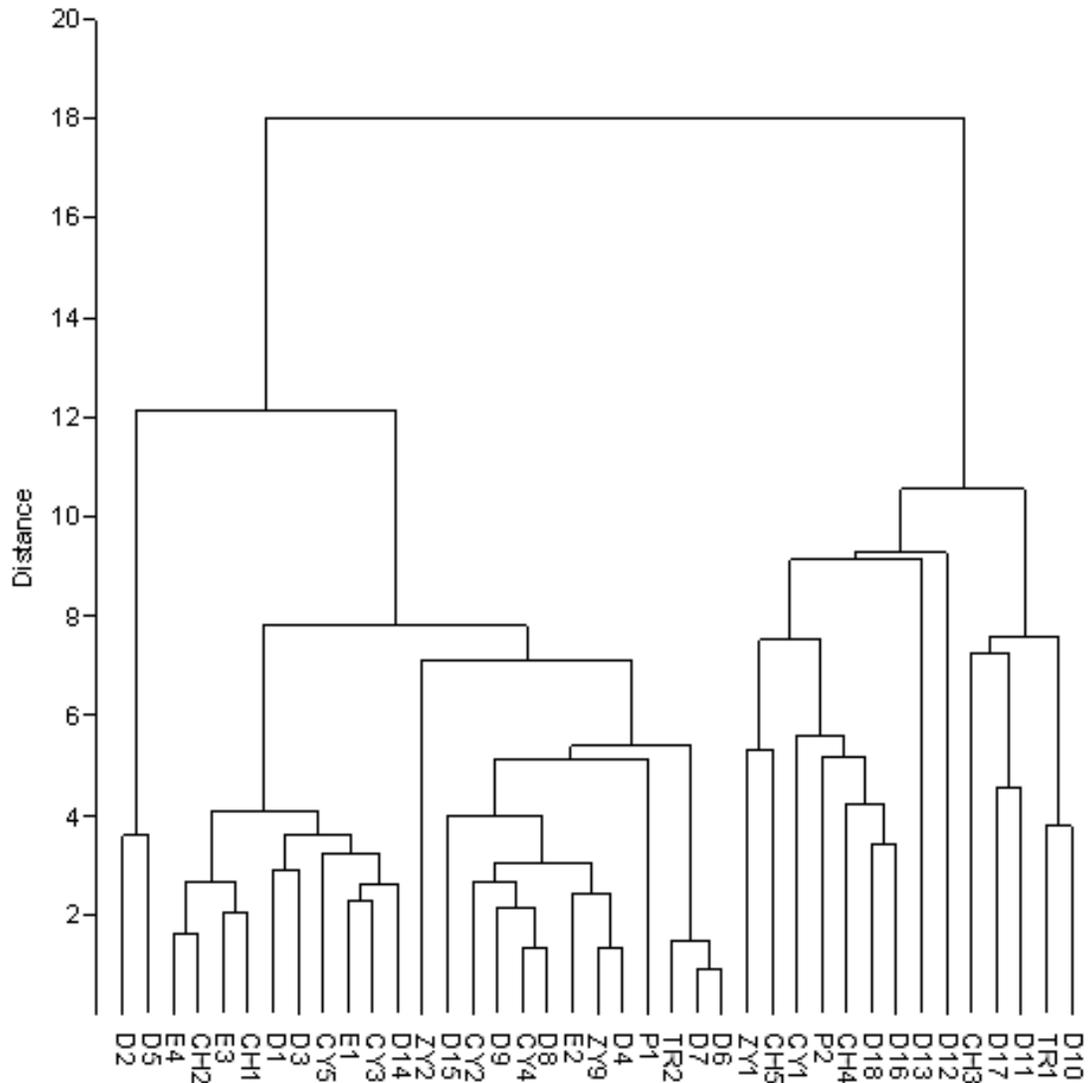


Figure 4. Cluster analysis of 39 recorded phytoplankton species.

apparent good health of the environment (Simboura and Zenetos, 2002). Species richness obtained appeared lower than that of Lake Azili (51 species) (a Lake located in the same basin of Ouémé) with the same method of study (Houssou et al., 2015).

The identified species are cosmopolitan with wide distribution. The typology allowed to see that species such as: *Melosira* sp., *N. sigma*, *S. acus*, *S. splendens*, *Closterium* sp. and *Closteriopsis* sp. are characteristic of the ecosystem and are not affected by the season. Most of the taxa in genus *Nitzschia* including *N. sigma* are  $\alpha$ -mesopolysaprobe. They are known to proliferate in eutrophic and hypertrophic environments (Leland

and Porter, 2000). In this study, density of species of genus *Nitzschia* including the characteristic (*N. sigma*) is still low. This is justified by the low accessibility of the lake, limiting exogenous inputs from anthropogenic sources (Houssou et al., 2016). Similarly, diatoms generally proliferate in favor of mineralized organic matter. The relatively low abundance of diatoms characteristics of the lake therefore reflects a low mineralization in the ecosystem.

The presence of a number of potentially toxic or toxin producing species in the lake could draw attention to the monitoring of the ecosystem. An increase in pollutant may lead to Lake Hlan

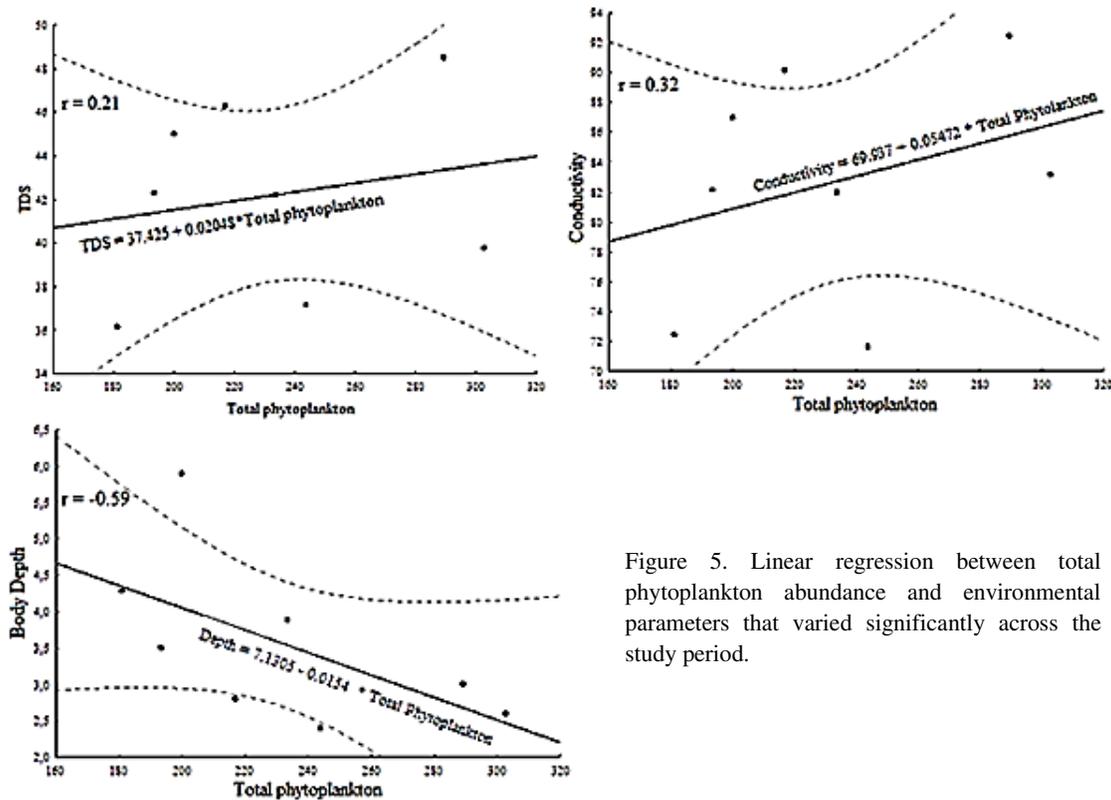


Figure 5. Linear regression between total phytoplankton abundance and environmental parameters that varied significantly across the study period.

degradation in favor of a proliferation of harmful species. Cyanobacteria, *Oscillatoria* species are known as toxin-producing as microcystins, anatoxin and aplysiatoxines and lipopolysaccharide (Chorus and Bartrum, 1999). The genus *Microcystis* is a producer of microcystins and lipopolysaccharide. These toxins in aquatic environments can cause several physiological damages on aquatic life. These effects can be direct or indirect with acute or chronic toxicity depending on the toxin. According Djediat et al. (2010), microcystins are responsible for cell lysis of the liver, hepatocyte vacuolation and loss of reserves (glycogen and glycoproteins) in fish. On human health, cyanotoxins may have effects of different levels (body irritation to food poisoning) according to the type of exposure. Similarly, the identified dinoflagellate species are potentially harmful. Thus appear the importance of monitoring Hlan Lake ecosystem not only for maintaining biodiversity but also for preserving the health of surrounding human populations.

The environmental factors effects on the abundance of the total phytoplankton were not very important due to low mineralization of the ecosystem

(Houssou et al., 2016). Illustrated by the low correlation of phytoplankton with TDS ( $r=0.21$ ) and conductivity ( $r=0.32$ ). The conductivity values recorded during the study were below of  $200 \mu\text{S cm}^{-1}$ . These values showed low impacts due to human activities (CREL, 2009-2011). Similarly TDS values are relatively low due to the strong bond between the two parameters. In view of the link between phytoplankton and water depth, the effect of the flood on the population is thus justified.

In summary, the phytoplankton species identified in the lake Hlan during this study are generally cosmopolitan. Some of them are producing toxin and therefore predispose the lake to a degradation of its ecosystem in case of significant input of organic matter. It is therefore essential to control the exogenous inputs into the lake. Based on the observed diversity, Hlan Lake is a balanced ecosystem. A thorough study of the phytoplankton compartment will therefore allow appreciating the real level of the ecosystem health.

### Acknowledgements

We are grateful to all colleagues who have

contributed in any way to the success of this study. We are also grateful to any reviewer who has contributed to the scientific approach of the paper.

## References

- Atanle K., Bawa M.L., Kokou K., Djaneye-Boundjou G. (2012). Caractérisation physico-chimique et diversité phytoplanctonique des eaux du lac de Zowla (Lac Boko), Togo. *International Journal of Biological and Chemical Sciences*, 6(1): 543-558.
- Atanle K., Bawa M.L., Kokou K., Djaneye-Boundjou G., Etorh M.T. (2013). Distribution saisonnière du phytoplancton en fonction des caractéristiques physico-chimiques du lac de Zowla (Lac Boko) dans le Sud-Est du Togo: cas de la petite saison sèche et de la grande saison sèche. *Journal of Applied Biosciences*, 64: 4847-4857.
- Barinova S.S., Tavassi M., Nevo E. (2005). Algal indicator system of environmental variables in the Hadera River basin, central Israel. *Plant Biosystems*, 140(1): 65-79.
- Barinova S.S., Medvedeva L.A., Anissimova O.V. (2006). Diversity of algal indicators in the environmental assessment. *Pilies Studio*, Tel Aviv, 498 p.
- Barinova S.S., Nevo E. (2012). Climatic and pollution impact on algal diversity of the freshwater ecosystems in Eurasia. In: *Climate Change and Impacts*. Cheyenne W.Y., USA. Academy Publish. org. pp: 16-50.
- Bennouna A., Assobhei O., Berland B., El Attar J. (2000). Étude des populations phytoplanctoniques de la lagune de Oualidia (Maroc); dinoflagellés potentiellement nuisibles. *Marine Life*, 10(1-2): 3-18.
- Bellinger E.G., Sigeo D.C. (2010). *Freshwater algae, Identification and use as bioindicators*. Wiley-Blackwell, John Wiley and Sons. 285 p.
- Chorus I., Bartrum J. (1999). *Toxic Cyanophyta in Water: A guide to their public health consequences, monitoring and management*. London and New York, Spon Press. 400 p
- Compère P. (1974). Algues de la région du lac Tchad, II: Cyanophycées. *Cahier O.R.S.T.O.M. Série Hydrobiologie*, 8(3-4): 165-198.
- Compère P. (1975). Algues de la région du lac Tchad, IV: Diatomophycées. *Cahier O.R.S.T.O. Série Hydrobiologie*, 9(4): 205-290.
- CREL (Conseil Régional de l'Environnement des Laurentides). (2009-2011). *Rapport d'interprétation des résultats. Lac des Beccs-Scie, Municipalité de Saint-Sauveur. Suivi complémentaire de la qualité de l'eau du programme Bleu Laurentides*.
- Djediat C., Malécot M., de Luze A., Bernard C., Puiseux-Dao S., Edery M. (2010). Localization of microcystin-LR in medaka fish tissues after cyanotoxin gavage. *Toxicon*, 55: 531-535.
- Frontier S. (1973). Statistical study of zooplankton dispersion. *Journal of Experimental Marine Biology and Ecology*, 12: 229-262.
- Gao X., Song J. (2005). Phytoplankton distributions and their relationship with the environment in the Changjiang Estuary, China. *Marine Pollution Bulletin*, 50: 327-335.
- Houssou A.M., Agadjihouédé H., Montchowui E., Bonou C.A., Lalèyè P. (2015). Structure and seasonal dynamics of phytoplankton and zooplankton in Lake Azili, small Lake of the pond of River Ouémé, Benin. *International Journal of Aquatic Biology*, 3(3): 161-171.
- Houssou A.M., Yaovi R., Ahouansou Montcho S., Bonou C.A., Montchowui E. (2016). Diversity and seasonal variation of zooplankton of Lake Hlan, Republic of Bénin (West Africa). *Journal of Applied Biosciences*, 102: 9723-9737.
- Kemka N., Njine T., Zébazé Togouet S.H., Niyitegeka D., Nola M., Monkiedje A., Demannou J., Foto Menbohan S. (2004). Phytoplankton du lac municipal de Yaoundé (Cameroun): Succession écologique et structure des peuplements. *Journal of Water Science*, 17(3): 301-316.
- Kinross J. (2007). Summary investigation on the phytoplankton of the Rivers Almond and Creran, Available at <http://www.algalweb.net/algweb1.htm> (accessed June 26th, 2012).
- Leland H.V., Porter S.T. (2000). Distribution of benthic algae in the Illinois River basin in relation to geology and land use. *Freshwater Biology*, 44: 279-301.
- Madhu N.V., Jyothibabu R., Balachandran K.K., Honey U.K. Martin G.D., Vijay J.G., Shiyas C.A., Gupta G.V.M., Achuthankutty C.T. (2007). Monsoonal impact on planktonic standing stock and abundance in a tropical estuary (Cochin backwaters-India). *Estuarine, Coastal and Shelf Science*, 73: 54-64.
- Maestrini S.Y., Robert J.M. (1981). Rendements d'utilisation des sels nutritifs et variations de l'état des cellules de trois diatomées de Claire à huîtres de Vendée. *Oceanologica acta*, 4(1): 13-22.

- Montchowui E., Chikou A., Kogbeto M-J., Laleye P. (2008). Biodiversité et structure des communautés de poissons du lac Hlan au Bénin, *International Journal of Biological and Chemical Sciences*, 2(2): 196-206.
- Nogueira N.M.C., Correia F.M.M. (2000). Cyanophyceae /Cyanobacteria in red mangrove forest at mosquitos and coqueiros estuaries, são luís, state of maranhão, Brazil. *Brazilian Journal of Biology*, 61: 1519-6984.
- Oyadomari J. (2011). Diatom Gallery. Keweenaw Waterway at MTU Surface plankton two. Available at <http://www.keweenawalgae.mtu.edu/index.htm> (accessed June 26th 2012)
- Prescott G.W. (1954). The freshwater algae. Pictured key, Nature series. Ed. H.E. Jaques. 224 p.
- Simboura N., Zenetos A. (2002). Benthic indicators to use in ecological quality classification of Mediterranean soft bottom marine ecosystems, including a new biotic index. *Mediterranean Marine Sciences*, 3: 77-111.
- Tsukii Y. (2005). Gomphonema vibrio Ehrenberg, Cell body. Available at <http://www.protist.i.hosei.ac.jp/protist/menuE.html> (accessed July 12th 2012).
- VanLandingham S.L. (1982). Guide to the identification, environmental requirements and pollution tolerance of freshwater blue-green algae (Cyanophyta). Environmental Monitoring and Support Laboratory, Office of Research and Development, US Environmental Protection Agency, USA. 349 p.