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REGULAR ARTICLE

PHYTOPLANKTON COMPOSITION OF A SHALLOW AFRICAN TROPICAL RESERVOIR (ADZOPÉ, CÔTE D'IVOIRE)

M. P. Adon[1], A. Ouattara[2], G. Gourene[2]*

Addresses: [1] Université d'Abobo - Adjamé, UFR Sciences et Gestion de l'Environnement, Laboratoire d'Environnement et de Biologie Aquatique, 02 BP 801 Abidjan 02, Côte d'Ivoire, phone number: (225) 01 72 54 70

[2] Université d'Abobo - Adjamé, UFR Sciences et Gestion de l'Environnement, Laboratoire d'Environnement et de Biologie Aquatique, 02 BP 801 Abidjan 02, Côte d'Ivoire.

*Coresponding author: adonmariepaulette@yahoo.fr

ABSTRACT

Phytoplankton of the Adzopé reservoir was investigated from May 2008 to February 2009. Samples were taken seasonally from 4 sampling stations. A total of 212 taxa belonging to 6 divisions have been identified, including Chlorophyta (35.38 % of taxa), Euglenophyta (29.25 %), Bacillariophyta (18.40 %), Cyanoprocaryota (10.85 %), Xanthophyta (5.19 %) and Pyrrhophyta (2.36 %). The greatest species richness was found in the central zone at S3 (205 taxa) and the smallest was recorded in the upper zone at station S1 (165 taxa). In the remaining stations were collected 173 (S2) and 195 (S4) taxa. At all the stations, the phytoplankton community was typically dominated by the pelagic-benthic species of Bacillariophyta (17 taxa) and pelagic species of Euglenophyta (43 taxa) and Chlorophyta (41 taxa). Spatio-temporal patterns of phytoplankton groups showed that Euglenophyta and Chlorophyta were permanent groups whatever the stations and seasons except stations S1 and S2 in long rainy season, where Chlorophyta accounted for 9.1 and 12.5 % of sporadic taxa respectively.

Keywords: phytoplankton, shallow reservoir, species richness, West Africa

INTRODUCTION

Phytoplankton is usually at the base of aquatic food web and is the most important factor for production of organic matter in aquatic ecosystem. Most reservoirs will require significant amount of phytoplankton to have productive and sustainable fisheries. The interplay of physical, chemical and biological properties of water most often lead to the production of phytoplankton, while their assemblage (composition and distribution) is also structured by these factors. The importance of phytoplankton in tropical reservoir ecosystems include its use in estimating potential fish yield (**Descy *et al.*, 2005**), productivity (**Park *et al.*, 2003**), water quality (**Walsh *et al.*, 2001**), energy flow (**Simciv, 2005**), trophic status (**Reynolds, 1999**) and management (**Beyruth, 2000**). These reservoirs are increasingly threatened by human activities (**Cecchi, 2007; Descy and Sarmento, 2008**). In Côte d'Ivoire, about 500 small reservoirs have been constructed on most river systems for water supplies and are presently considered to be threatened (**Aka *et al.*, 2000**). In spite of this, little is known about the ecology of small reservoirs in Côte d'Ivoire, even though many aquatic habitats are being degraded by pollution, siltation and other human activities (**Cecchi, 2007**). Water resources in these reservoirs are utilized for drinking, washing, bathing, and irrigation purposes. They receive run-off and wastewater discharges from agriculture and domestic uses. The only published account of Ivorian small reservoirs, a survey of the reservoir of Agboville, clearly showed the impact of river regulation, pollution and emphasized the need for further investigations (**Gone *et al.*, 2010**). Therefore, the present investigation has attempted to study the water quality in relation to the phytoplankton in the reservoir of Adzopé. This reservoir was selected because it is surrounded by Adzopé city and there are major activities in the vicinity on its catchment.

The literature on freshwater algae of Ivory Coast is scarce and limited to a few areas. Vast areas remain unexplored. In addition the extreme diversity of aquatic ecosystems necessitates a constant knowledge of freshwater algae. Most of the inventory works in the stagnant waters were conducted in large hydroelectric reservoirs (**Traoré, 1979; Ouattara *et al.*, 2000**) or hydro-agricultural (**Uherkovich and Rai, 1977; Cecchi, 2007**). In shallow reservoirs this type of study is rare so an overview is failing us on algae. The only works on these ecosystems are not limited only to those of **Bourrelly (1961)** in some ponds and **Da *et al.* (1997, 1999)** in fish ponds. In shallow Adzopé's reservoir or pressure from human is notable, it seems interesting to assess the diversity of phytoplankton community.

The aim of this study was to examine the phytoplankton variability throughout year in Adzopé's reservoir.

MATERIAL AND METHODS

Study area and sampling stations

Adzopé Reservoir (6°10'52" and 6°12'15" N and 3°85'65" and 3°86'73" W) is located in the south-east of Côte d'Ivoire that belongs to the subequatorial zone (**Iltis and Lévêque, 1982**), characterized by four climatic seasons: long rainy season (April-July); short dry season (August-September); short rainy season (October-November); long dry season (December-March). It is led by the temporary rivers inflow and direct run-off during the rainy season. The dwelling sewage flows though permanently into the reservoir. The total area of the reservoir is estimated at 61.44 hectares. The reservoir has a mean depth of 4.91 m and a length of about 2 km. Bank around the reservoir is often occupied by dwelling and market gardening. The hydrological regime of this reservoir depends on precipitations.

Four representative stations (S1, S2, S3, S4) were sampled according to the longitudinal gradient (Fig. 1). S1 was located in the upper zone of the reservoir (close to 2.7 m average depth), S2 (4.1 m) and S3 (6.3 m) in the central zone, and S4 (6.5 m) in a down zone, near the dyke.

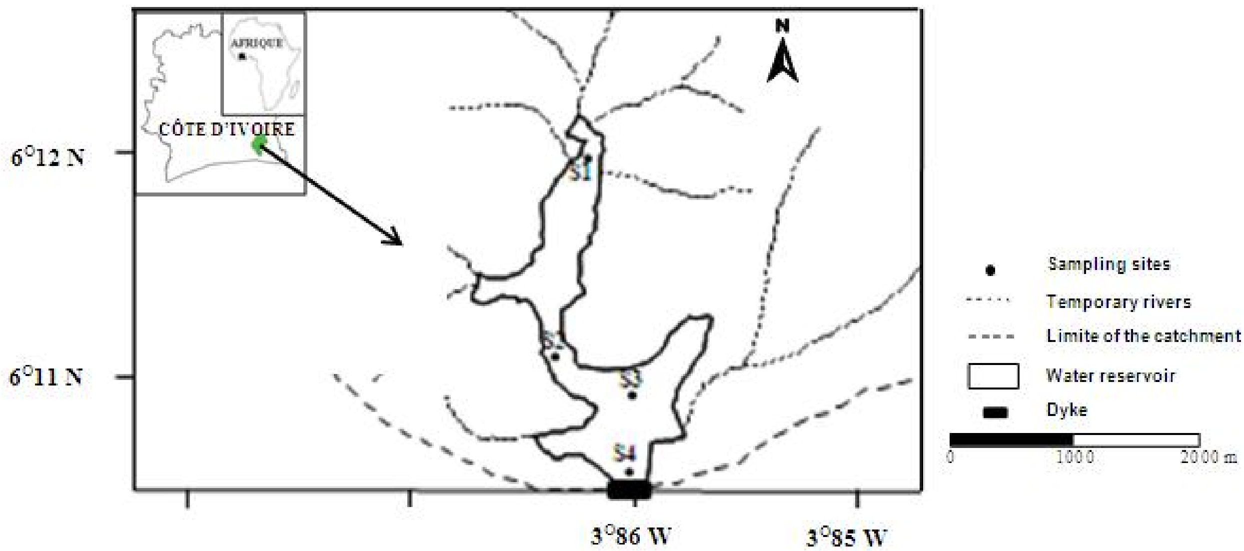

Figure 1 Adzopé reservoir showing the sampling sites (UTM, Universal Transverse Mercator)

Sampling and identification of phytoplankton

At each station, four samplings were carried out in order to represent the four climatic seasons: May 2008 for long rainy season (LRS), September 2008 for short dry season (SDS), November 2008 for short rainy season (SRS) and February 2009 for long dry season (LDS) (Fig. 2).

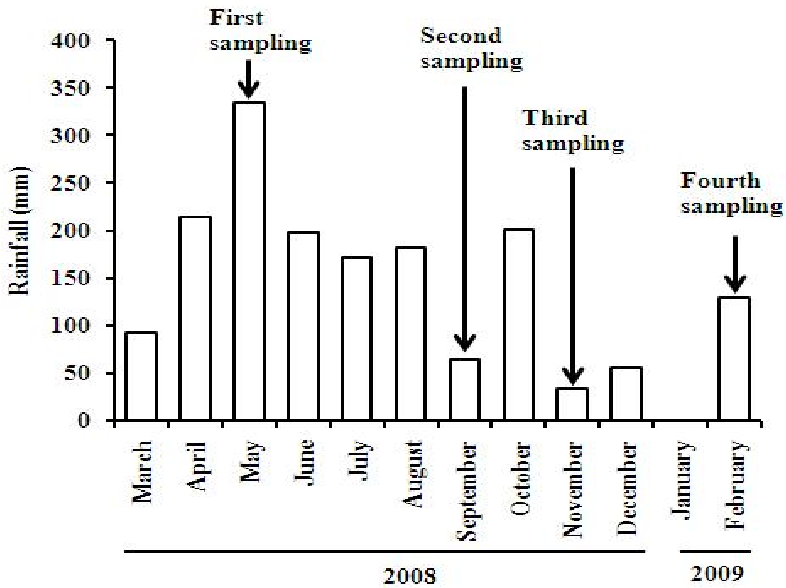

Figure 2 Monthly rainfall data from May 2008 to March 2009 recorded at the study area obtained from the SODEXAM. The arrows indicate the sampling periods

For each sample, sub-samples of 50 mL were gathered between 06:00 and 09:00 AM with 2.5 L Van Dorn bottle from the surface of water and preserved with 200 µL Lugol's solution. These samples were examined in the laboratory using an OLYMPUS BX40 microscope equipped with tracing and measuring devices. Before microscopic identifications, organic substances on the samples were removed using HNO_3^- for diatoms (**Leclercq and Maquet, 1987; Rumeau and Coste, 1988; Prygiel and Coste, 2000**). The species were identified under microscope OLYMPUS BX40 and classification was done with standard works (**Compère, 1989; Ouattara *et al.*, 2000**) and more specific literature (**Couté and Iltis, 1981; Carter and Denny, 1982; Komárek and Fott, 1983; Compère, 1986; Krammer and Lange-Bertalot, 1991; Uherkovich, 1995; Da *et al.*, 1997; Marin *et al.*, 2003; Komárek *et al.*, 2003, Komárek and Anagnostidis, 2005**).

Data analysis

Grouping of phytoplankton species in terms of frequency coefficient was used following frequency groups to show the presence frequency of species in the community during the year. Three frequency groups were noted according to value of F (**Dajoz, 2000**) : F > 50 % : continuous species; 25 % < F < 50 %: common species; F < 25 % : rare species in the community. Frequency was calculated with the following equality:

$$F = \frac{F_i}{F_t} \times 100$$

F_i: presence number of i species in total sampling; F_t: total number of sampling of whole species.

RESULTS AND DISCUSSION

Phytoplankton composition

The phytoplankton of Adzopé reservoir consisted of 212 taxa belonging to six divisions: Cyanoprocaryota, Euglenophyta, Chlorophyta, Pyrrhophyta, Xanthophyta and Bacillariophyta. Chlorophyta (75 taxa, 35.38%) and Euglenophyta (62 taxa, 29.25%) were more represented in the phytoplankton. The remaining divisions were as follows: Bacillariophyta (39 taxa, 18.40%), Cyanoprocaryota (23 taxa, 10.85%), Xanthophyta (11 taxa, 5.19%) and Pyrrhophyta (5 taxa, 2.36%). A list of main phytoplankton species is given in Table 1. In terms of species number, Chlorophyta and Euglenophyta were more diversified followed by Bacillariophyta and Cyanoprocaryota. A total of 79 genera were found in the phytoplankton with Chlorophyta, Bacillariophyta and Cyanoprocaryota having the highest genera each, while Euglenophyta and Xanthophyta had 6 genera respectively. Pyrrhophyta was the last with three genera. Among Chlorophyta, Chlorococcales with 48 taxa were more diversified. The following genera are richest in terms of species: among the Chlorococcales - *Scenedesmus* (9 taxa), *Tetraedron* (9 taxa) and *Dictyosphaerium* (4 taxa). Among the Euglenophyta, genus *Trachelomonas* was the most taxa-rich group with 29 taxa, followed by *Phacus* (19 taxa), *Euglena* and *Strombomonas* with 4 taxa each. The other groups were more represented by: 11 taxa belonging to Naviculales following by 8 taxa of Cymbellales and 7 taxa of Bacillariales from Bacillariophyta; 17 taxa of Chroococcales from Cyanoprocaryta; 8 taxa of Mischococcales from Xanthophyta and 2 taxa of Cryptomonadales and Gymnodiniales each from Pyrrhophyta. Among Bacillariophyta, the genera *Pinnularia* and *Nitzschia* with 6 taxa each, *Eunotia* (5 taxa) and *Gomphonema* (4 taxa) were more diversified. Genus *Microcystis* (4 taxa) was superior to the other genera in terms of diversity from Cyanoprocaryota. The Xanthophyta were composed mainly of genus *Pseudostaurastrum* with 3 taxa. The greatest diversity of Pyrrhophyta species was found mainly for the genera *Cryptomonas* and *Karenia* with 2 taxa each.

The highest number of taxa (205) was recorded in central zone at station S3, while the lowest number of taxa (165) was found in upper zone at station S1. In the remaining stations were collected 173 (S2) and 195 (S4) taxa. Among phytoplankton algae, 145 taxa (68.40%) were common to all stations. They are mainly Chlorophyta (47 taxa), Euglenophyta (43 taxa), Bacillariophyta (33 taxa), Cyanoprocaryota (15 taxa), Pyrrhophyta and Xanthophyta with 3 taxa each. According to the results of frequency coefficients in the community structure of the phytoplankton species, 61, 60 and 61% were common in stations S1 (upper zone), S2 (central zone) and S4 (down zone) respectively. At these same stations, percentage of continuous species covered 39, 40 and 39% of the taxinomic richness. On the other hand, in station S3, rare species (85 taxa, 41%) were more numerous than continuous (67 taxa, 33%) and common (53 taxa, 26%) species respectively.

The distribution of the phytoplankton algae in the different habitat of stations is summarized in Table 2. Bacillariophyta with 11 taxa at all stations were more represented in the benthic habitat while 17 taxa at S1, 18 taxa at stations S2 and S4 respectively, 20 taxa at S3 were more diversified in both pelagic and benthic habitat. Euglenophyta and Chlorophyta were exclusively pelagic at all stations of Adzopé's reservoir. A proportion rather close to Cyanoprocaryota and Bacillariophyta was noted in both pelagic and benthic habitat at station S1. In contrast, a large diversity of Euglenophyta (41%) and Chlorophyta (40%) was observed exclusively in the pelagic zone. A similar proportion of Euglenophyta and Chlorophyta in stations S2, S3 and S4 to that of S1 were obtained.

Table 1 List of main phytoplankton species in Adzopé's reservoir.

TAXONS	Habitat			F			
CYANOPROCARYOTA	B	P	B+P	S1	S2	S3	S4
Anabaena constricta Szafer (Geitler)		****		Co	Co	Co	Co
EUGLENOPHYTA							
Euglena oxyuris Schm.		****		Co	Co	Co	Co
Lepocinclis acus (O. F. Müller) Marin et Melkonian		****		Co	Co	Co	Co
Lepocinclis texta (Duj.) Lemm. emend. Conrad		****		Co	Co	Co	Co
Phacus acuminatus Stokes		****		Co	Co	Co	Co
Phacus tortus (Lemm.) Skv.		****		Co	Co	Co	Co
Phacus sesquitortus Pochm.		****		Co	Co	Co	Co
Phacus suecicus Lemm.		****		Co	Co	Co	Co
Phacus sp.		****		Co	Co	Co	Co
Trachelomonas volvocina Ehr.		****		Co	Co	Co	Co
Trachelomonas oblonga Lemm.		****		Co	Co	Co	Co
Trachelomonas hispida var. *coronata* Lemm.		****		Co	Co	Co	Co
Trachelomonas hispida var. *crenulaticollis* (Mask.) Lemm.		****		Co	Co	Co	Co
Trachelomonas raciborskii Wol.		****		Co	Co	Co	Co
Trachelomonas lefevrei Defl.		****		Co	Co	Co	Co
CHLOROPHYTA							
Monoraphidium arcuatum (Korš.) Hind.			****	Co	Co	Co	Co
Crucigeniella crucifera (Wolle) Kom.		****		Co	Co	Co	Co
Crucigenia tetrapedia (Kirchn.) W. & West		****		Co	Co	Co	Co
Scenedesmus obtusus Mey. f. *alternans*		****		Co	Co	Co	Co
Scenedesmus acutiformis Schröd.		****		Co	Co	Co	Co
Tetraedron triangulare Korš.		****		Co	Co	Co	Co
Staurastrum volans West		****		Co	Co	Co	Co
Cosmarium contractum Kirchn.		****		Co	Co	Co	Co
PYRROPHYTA							
Karenia sp. 2		****		Co	Co	Co	Co
Peridinium cinctum (O.F. Müller) Ehrenbg.		****		Co	Co	Co	Co

BACILLARIOPHYTA							
Fragilaria crotonensis Kitton		****		Co	Co	Co	Co
Ulnaria biceps (Kütz.) Comp.		****		Co	Co	Co	Co
Ulnaria ulna (Nitzsch) Comp.		****		Co	Co	Co	Co
Nitzschia palea (Kütz.) Smith	****			Co	Co	Co	Co
XANTHOPHYTA							
Goniochloris mutica (Br.) Fott		****		Co	Co	Co	Co
Tetraëdriella gigas (Pascher) Fott		****		Co	Co	Co	Co

Legend:

B: benthic; P: pelagic; F: percentage of occurrence; ****: presence at all stations; Co: continuous species; S1, S2, S3 and S4: stations

Table 2 Distribution of the phytoplanktonic phyla in different stations of Adzopé's reservoir.

	Stations																											
	S1							S2							S3							S4						
Phyla	T	B	P	Pe	P	B + P	P	T	B	P	Pe	P	B + P	P	T	B	P	Pe	P	B + P	P	T	B	P	Pe	P	B + P	P
Cyano	16	1	7	12	10	5	17	19	2	13	11	9	7	21	23	2	12	13	9	8	22	20	2	12	13	9	6	18
Eugle	50	0	0	50	41	0	0	52	0	0	52	42	0	0	59	0	0	59	40	0	0	58	0	0	58	40	0	0
Chloro	57	3	20	49	40	6	21	57	2	13	49	39	6	18	73	4	24	61	41	8	22	70	4	24	59	41	7	21
Pyrrho	3	0	0	3	2	0	0	3	0	0	3	2	0	0	5	0	0	5	3	0	0	5	0	0	5	3	0	0
Bacill	35	11	73	5	4	17	59	35	11	74	5	4	18	55	38	11	65	5	3	20	56	36	11	64	5	3	18	55
Xanth	4	0	0	3	2	1	3	7	0	0	5	4	2	6	7	0	0	6	4	0	0	6	0	0	4	3	2	6
Total	165	15	100	122	100	29	100	173	15	100	125	100	33	100	205	17	100	149	100	36	100	195	17	100	144	100	33	100

Legend:

Cyano: Cyanoprocaryota; Eugle: Euglenophyta; Chloro: Chlorophyta; Pyrrho: Pyrrophyta; Bacill: Bacillariophyta; Xanth: Xanthophyta; T: Total; B: benthic; Pe: pelagic; P: proportion in terms of richness of the species in the community

Spatio-temporal patterns of phytoplankton in Adzopé's reservoir

The seasonal distribution in phytoplankton of the four stations in Adzopé's reservoir was presented in Figure 3. Euglenophyta and Chlorophyta were most predominant group, followed by Xanthophyta. Cyanoprocaryota, Pyrrhophyta and Bacillariophyta were the least diverse group varying between 0 and 18% of the total taxinomic richness and represented at all stations sporadic taxa. Their proportions were ranged between 4 and 18% for Cyanoprocaryota, between 0 and 6% for Pyrrhophyta and between 0 and 8.5% for Bacillariophyta. In contrast, Euglenophyta and Chlorophyta were permanent group at all stations and seasons except stations S1 and S2 in long rainy season, where Chlorophyta accounted for 9.1 and 12.5% of sporadic taxa respectively. Among Xanthophyta, permanent taxa were observed at stations S1 in long rainy season (14 taxa, 29.79%) and long dry season (23 taxa, 37%), S2 during long dry season (16 taxa, 27.59%) and station S4 in short dry season (29 taxa, 35.80%) and long dry season (12 taxa, 25%). Others taxa were sporadic.

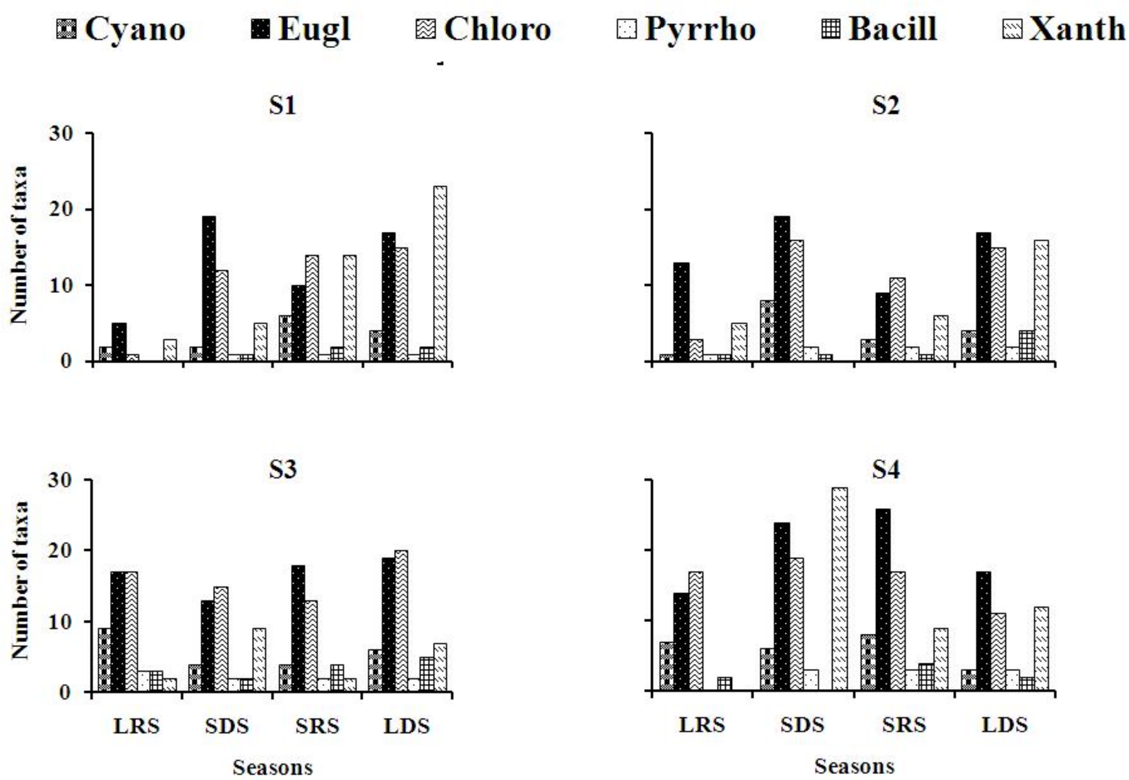

Figure 3 Spatial and seasonal distribution of the specific richness from Adzopé reservoir

DISCUSSION

The algal flora from Adzopé's reservoir can be considered as rich in the number of taxa (212). This richness may be related to the fact that the waters of the reservoir are stagnant. Indeed, the development of phytoplankton communities is highly dependent on the stability of the water column. In addition, the stagnant nature of the lakes promotes biological processes such as complete cycles of reproduction and development of algae (**Ouattara, 2000**). This diversity of taxa is higher than that obtained by **Bouvy *et al.* (1998)** in three shallow reservoirs in northern of Côte d'Ivoire (54 taxa), **David and David (2002)** in Lake Naivasha from Kenya (170 taxa), **Bouvy *et al.* (2006)** in Lake Guiers from Senegal (111 taxa), **Abbas (2009)** in the reservoir Himreen from Iraq (98 taxa). This difference could be allotted to the sampling procedure used in these aquatic ecosystems. Indeed, these authors for the majority carried out a sampling on the water surface (epilimnion). In our study, surface water sampling was realized, but particularly both nycthemeral cycle and vertical sampling were carried out contributing to collect a number of taxa which would enrich the phytoplanktonic community.

In terms of species composition, Chlorophyta and Euglenophyta are the most diversified at all stations of Adzopé's reservoir. This diversity of Chlorophyta and Euglenophyta has been reported in Samuel reservoir, Brazil (**Matsumura-Tundisi *et al.*, 1989**), in Petit-Saut reservoir, Guyane Française (**Vaquer *et al.*, 1997**), in shallow reservoirs from central and northern of Côte d'Ivoire **(Bouvy *et al.*, 1998; Arfi *et al.*, 2001)**, in the lake Guiers, Senegal (**Bouvy *et al.*, 2006**), and in the waters of lakes flood plains of Brazil (**Nabout *et al.*,. 2006**). The high number of Chlorophyta is due to high diversity of Chlorococcales (54 taxa) observed in this group. In addition, the physical and chemical characteristics of reservoir are favorable a specific diversification of Chlorophyta. Indeed the Chlorophyta are typically thermophilous and photophilic (**Cabioc'H *et al.*, 1992; Sheath and Wehr, 2003**). The high diversity of Euglenophyta can also be explained by the impact of external and internal flows in the reservoir so the organic matter available (**Kim and Boo, 1998; Dia and Reynaud, 1982**).

The floristic composition of different stations from Adzopé's reservoir is similar. Similarity may be related to the similarity of physical and chemical parameters necessary for their development in all stations sampled. This result is also observed in the Oyun reservoir of Nigeria (**Moshood, 2009**). However, the phytoplankton composition showed that Bacillariophyta are diversified in the pelagic-benthic habitat than exclusively in the benthos.

Bacillariophyta are more diversified in freshwater since they have the capacity to increase with the mixture of the water column (**Smayda, 1997; Smayda and Reynolds, 2001**). Moreover, the mixture of the water column would favour the pulling up of Bacillariophyta of the supports which could's be there. **Adon *et al.* (2011)** has reported that the reservoir examined in this study is too shallow to stratify thermally and is all well mixed system.

Although the general inventory of the phytoplanktonic algae for Adzopé's reservoir is not exhaustive, this study provides essential elements to the knowledge of phytoplankton from reservoir which there are only partial inventories made by **Kouassi *et al.* (2010)**.

CONCLUSION

Phytoplankton data in tropical shallow reservoir are scarce. The present study allowed drawing up a first inventory of phytoplankton taxa of the Adzopé reservoir and proposes a pattern of the spatio-temporal variability of the phytoplankton community. The algal flora was rich in the number of taxa (212) due to the fact that the waters of the reservoir are stagnant. This was also related to the sampling method used in this study. Whatever the station and seasons, Euglenophyta and Chlorophyta were permanent groups probably related to the environmental conditions which theirs are favorable. In contrast, Bacillariophyta (17 taxa) were the most diversified in the pelagic-benthic habitat than exclusively in the benthos because of their capacity to proliferated with the mixture of the water column.

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REFERENCES

ABBAS, M. I. 2009. Species Composition and Seasonal Variation of Phytoplankton in the Himreen Reservoir in the Middle of Iraq. In *University of Sharjah Journal of Pure & Applied Sciences*, vol. 6, 2009, no. 1, p. 35-44.

ADON, M. P. - OUATTARA, A. - GOURENE, G. 2011. Seasonal variation in the diversity and abundance of phytoplankton in a small African tropical reservoir. In *African Journal of Microbiology Research*, vol. 5, 2011, no. 18, p. 2616-2626.

AKA, M. - PAGANO, M. - SAINT-JEAN, L. - ARFI, R. - BOUVY, M. - CECCHI, P. - CORBIN, D. - THOMAS, S. 2000. Zooplankton variability in 49 shallow tropical reservoirs of Ivory Coast (West Africa). In *International Revue Hydrobiologie*, vol. 85, 2000, no 4, p. 491-504.

ARFI, R. - BOUVY, M. - CECCHI, P. - PAGANO, M. - THOMAS, S. 2001. Factors limiting phytoplankton productivity in 49 shallow reservoirs of North Côte d'Ivoire (West Africa). In *Aquatic Ecosystem Health and Management Society*, vol. 4, 2001, p. 123-138.

BEYRUTH, Z. 2000. Periodic disturbances, trophic gradient and phytoplankton characteristics related to cyanobacterial growth in Guarapiranga reservoir. Sao Paulo State, Brazil. In *Hydrobiologia*, vol. 424, 2000, p. 51-60.

BOUVY, M. - ARFI, R. - CECCHI, P. - CORBIN, D. - PAGANO, M. - SAINT-JEAN, L. - THOMAS, S. 1998. Trophic coupling between bacterial and phytoplanktonic compartments in shallow tropical reservoirs (Côte d'Ivoire, West Africa). In *Aquatic Microbial Ecology*, vol. 15, 1998, p. 25-37.

BOUVY, M. - BA, N. - KA, S. - SANE, S. - PAGANO, M. - ARFI, R. 2006. Phytoplankton community structure and species assemblage succession in a shallow tropical lake (Lake Guiers, Senegal). In *Aquatic Microbial Ecology*, vol. 45, 2006, p. 147-161.

CABIOC'H, J. - FLOC'H, J.-Y. - Le TOQUIN, A. 1992. Guide des algues des mers d'Europe. Delachaux et Niestlé (Eds), Paris: 1992, 231 p.

CARTER, J. R. - DENNY, P. 1982. Freshwater Algae of Sierra Leone. Part (i) Diatoms from the River Jong (Taia) at Njala: 1982, p. 198-252.

CECCHI, P. 2007. L'eau en partage: les petits barrages de Côte d'Ivoire. IRD (éd.). Collection latitudes 23. Paris: 2007, 295 p.

COMPERE, P. 1986. Flore pratique des algues d'eau douce de Belgique. Tome 1. Cyanophyceae. Jardin Botanique National de Belgique: 1986, 120 p.

COMPERE, P. 1989. Flore pratique des algues d'eau douce de Belgique. Tome 2. Pyrrhophytes : Cryptophyceae, Dinophyceae ; Raphidophytes : Raphidophyceae ; Euglenophytes : Euglenophyceae. Jardin Botanique National de Belgique: 1989, 209 p.

COUTE, A. - ILTIS, A. 1981. Ultrastructure de la logette de *Trachelomonas* (Algae, Euglenophyta) récoltés en Côte d'Ivoire. In *Revue Hydrobiologie Tropicale*, vol. 14, 1981, no. 2, p. 115-133.

DA, K. P. - TRAORE, D. - ASSEMIEN, P. 1997. Le genre *Scenedesmus* dans la microflore de la mare et du complexe piscicole du Parc National du Banco (Côte d'Ivoire). In *Bulletin Jardin Botanique Nationale de Belgique / Bulletin Nationale Plantentuin de Belgique*, vol. 66, 1997, p. 107-129.

DA, K. P. - TRAORE, D. - ASSEMIEN, P. 1999. Cyanophytes, Rhodophytes et Pyrrhophytes de la mare et du complexe piscicole du Parc National du Banco (Côte d'Ivoire). In *Systematics and Geography of Plants*, vol. 69, 1999, p. 161-183.

DAJOZ, R. 2000. Précis d'écologie. Septième édition. Paris: Dunod, 2000, 615 p.

DAVID, S. H. - DAVID, M. H. 2002. Phytoplankton community structure and succession in the water column of Lake Naivasha, Kenya: a shallow tropical lake. In *Hydrobiologia*, vol. 488, 2002, p. 89-98.

DESCY, J.-P. - HARDY, M.-A. - STÉNUITE, S. - PIRLOT, S. - LEPORCQ, B. - KIMIREI, I. - SEKADENDE, B. - MWAITEGA, S. R. - SINYENZA, D. 2005. Phytoplankton pigments and community composition in Lake Tanganyika. In *Freshwater Biology*, vol. 50, 2005, p. 668-684.

DESCY, J.-P. - SARMENTO, H. 2008. Microorgansms of the East African Great Lakes and their response to environmental changes. In *Freshwater Reviews*, vol. 1, 2008, p. 59-73.

DIA, A. - Reynaud, P. A. 1982. Le phytoplancton du lac de Guiers : approche qualitative et quantitative. *Cahier ORSTOM,* In *série Hydrobiologie*, 1982, no. 45, p. 35-47.

GONE, D. L. - KAMAGATE, B. - LIGBAN, R. - SAVANE I. - BIEMI J. 2010. Characterization of dissolved organic matter at different stages of a tropical surface water treatment using fluorescence spectroscopy (Agboville, Côte d'Ivoire). In *Journal of water and environment technology*, vol. 8, 2010, no. 1, p. 17-28.

ILTIS, A. - LEVËQUE, C. 1982. Caractéristiques physico-chimiques des rivières de Côte d'Ivoire. In *Revue Hydrobiologie Tropicale,* vol. 15, 1982, no. 2, p. 115-130.

KIM, J. T. - BOO, S. M. 1998. Morphology, population size, and environmental factors of two morphotypes in *Euglena geniculata* (Euglenophyceae) in Korea. In *Archiv für Hydrobiologie Supplement*, vol. 126, 1998, p. 27-36.

KOMÁREK, J. - ANAGNOSTIDIS, K. 2005. Cyanoprokaryota 2. Teil: Oscillatoriales. In BÜDEL, B. - GÄRTNER, G. - KRIENITZ, L. - SCHAGERL, M. (Hrsg.) Sübwasserflora von Mittelleuropa 19 (2). 2005, 759 p.

KOMÁREK, J. - KING, H. - KOMÁRKOVÁ, J. 2003. Filamentous cyanobacteria. In WEHR, J. D. - SHEATH, R. G.. (Eds.) Freshwater Algae of North America. Ecology and Classification. Academic Press. San Diego: California, 2003, p. 117-191.

KOMÁREK, J. - FOTT, B. 1983. Chlorophyceae (Grûnalgen) Ordnung : Chroococcales. In HUBER-PESTALOZZI G. (ed.) Das Phytoplankton des Sübwassers 7 (1). 1983, X+1044 p. 253 pl.

KOUASSI, B. A. T. - OUATTARA, A. - DA, K. P. - TRAORÉ, D. 2010. Taxonomy of Periphytic Zygophyceae occurring in the Adzopé reservoir, Côte d'Ivoire. In *Journal of Applied Biosciences*, vol. 34, 2010, p. 2198 - 2207 ISSN 1997-5902.

KRAMMER, K. - LANGE-BERTALOT, H. 1991. Bacillariophyceae. 3. Teil : Centrales, Fragilariaceae, Eunotiaceae. In Gustav Fisher Verlag Sü*β*wasserflora von Mitteleuropa 2/2. 1991, 576 p. 166 pl.

LECLERCQ, L. - MAQUET, B. 1987. Deux nouveaux indices chimique et diatomique de la qualité d'eau courante. Application au Samson et à ses affluents (Bassin de la Meuse belge). Comparaison avec d'autres indices chimiques, biocéniques et diatomiques. Institut Royal des Sciences Naturelles de Belgique, Document de travail, 28, 1987. 113 p.

MARIN, B. - PALM, A. - KLINGBERG, M. - MELKONIAN, M. 2003. Phylogeny and Taxonomic Revision of Plastid-Containing Euglenophytes based on SSU rDNA Sequence Comparisons and Synapomorphic Signatures in the SSU rRNA Secondary Structure. In *Protist*, 2003, no. 154, p. 99-145.

MATSUMURA-TUNDISI, T. - TUNDISI, J. G. - SAGGOI, A. - OLIVEIRA NETO, A. L. - ESPINDOLA, E. G. 1989. Limnology of Samuel Reservoir (Brazil, Rondonia) in the filling phase. In *Verhhandlungen des Internationalen Verein Limnologie*, 1989, p. 1482-1488.

MOSHOOD, K. M. 2009. Phytoplankton assemblage of a small, shallow, tropical African reservoir. In *Revista de Biología Tropical*, vol. 57, 2009, no. 4, p. 1009-1025.

NABOUT, J. C. - NOGUEIRA, I. S. - OLIVEIRA, L. G. 2006. Phytoplankton community of floodplain lakes of the Araguaia River, Brazil, in the rainy and dry seasons. In *Journal of Plankton Research*, vol. 28, 2006, no. 2, p. 181-193.

OUATTARA, A. 2000. Premières données systématiques et écologiques du phytoplancton du lac d'Ayamé (Côte d'Ivoire). Thèse de doctorat, Katholieke Universiteit Leuven. Belgique: 2000, 207 p.

OUATTARA, A. - PODOOR, N. - TEUGELS, G. G. - GOURENE, G. 2000. Les micro-algues de deux cours d'eaux (Bia et Agnébi) de Côte d'Ivoire. In *Systematics and Geography of Plants*, vol. 70, 2000, p. 315-372.

PRYGIEL, J. - COSTE, M. 2000. Guide méthodologique pour la mise en œuvre de l'Indice Biologique Diatomées NF T 90-354. Agences de l'Eau. 2000, 134 p.+89 pl.+cd rom TAX'IBD français/anglais.

REYNOLDS, C. S. 1999. Non-determinism to probability, or N:P in the community ecology of phytoplankton: Nutrient ratios. In *Archiv für Hydrobiologie*, vol. 146, 1999, p. 23-35.

RUMEAU, A. - COSTE, M. 1988. Initiation à la systématique des diatomées d'eau douce. Pour l'utilisation pratique d'un indice diatomique générique. In *Bulletin Française de Pêche et de Pisciculture,* vol. 309, 1988, p. 1-69.

SHEATH, R. G. - WEHR, J. D. 2003. Freshwater Algae of North America. Ecology and classification. California: U.S.A, 2003. 918 p.

SIMCIV, T. 2005. The role of plankton, zoobenthos, and sediment in organic matter degradation in oligotrophic and eutrophic mountain lakes. In *Hydrobiologia*, vol. 532, 2005, p. 69-79.

SMAYDA, T. J. 1997. What is a bloom? A commentary. In *Limnology and Oceanography*, vol. 42, 1997, no. 5 Supp. 2, p. 1132-1136.

SWAYDA, T. J. - REYNOLDS, C. S. 2001: Community assembly in marine phytoplankton; application of recent models to harmful dinoflagellate blooms. In *Journal of Plankton Research*, vol. 23, 2001, p. 447-461.

TRAORE, K. 1979. Caractéristiques limnologiques du lac Kossou (Côte d'Ivoire). Annale Universitaire d'Abidjan série E (XII) : 1979, p. 29-69.

UHERKOVICH, G. 1995. A scenedesmus zöldalga nemzetség (Chlorococcales, Chlorophyceae) különös tekintettel magyarországi elöfordulású taxonjaira. Ács Éva és Schmidt Antal Közremüködésével. Szerkesztette : Kiss Keve Tihamér. A könyv megjelenését a Magyar Könyv Alapítvány és a Nemzetközi. Limnológiai Társaság (SIL) támogatta. Magyar Algológiai Társaság. Budapest: 1995. 266 p.

UHERKOVICH, G. - RAI, H. 1977. Zur Kenntnis des phytoplanktons einiger Gewässer des Staates Elfenbeinküste (Afrika). I. Bouaké-Stausee. In *Archiv für Hydrobiologie*, vol. 81, 1977, p. 233-258.

VAQUER, A. - PONS, V. - LAUTIER J. 1997. Distribution spatio-temporelle du phytoplancton dans le réservoir de Petit-Saut (Guyane, Française). In *Hydroécologie Appliquée*, vol. 1/2, 1997, p. 169-193.

WALSH, C. J. - SHARPE, A. K. - BREEN, P. F. - SONNEMAN, J. A. 2001. Effects of urbanization on streams of the Melbourne region, victoria, Australia. I. Benthic macroinvertebrate communities. In *Freshwater Biological*, vol. 46, 2001, p. 535-551.