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Original Article

Composition and structure of phytoplankton community in Ouémé River basin, Republic of Benin

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Abstract: This study aimed to assess the composition and structure of floating phytoplankton assemblage in Ouémé basin. Phytoplankton samples were collected monthly from October 2014 to September 2015. Quantitative samples were taken with a horizontal Van-Dorn sampler and 20 µm mesh plankton net was used for additional qualitative sampling. Microscopic observation of phytoplankton allowed identification of 208 species including 70 Bacillariophyta species, 58 Chlorophyta species, 24 Charophyta species, 21 Euglenophyta species, 18 Cyanophytes species, 9 Phyrrophyta species, 5 Ochrophyta species and 3 Cryptophyta species. The Shannon diversity index varied from 2.4 bit.ind^{-1} and 3.1 bit.ind^{-1} showing a relatively good diversification of the community. The population appears largely dominated by 14 species which represent 83.8% of the total phytoplankton. *Aulacoseira granulata* and *Euglena gracilis* were the most predominant species with respectively 40.17% and 15.91% relative abundance. Regarding the horizontal pattern of phytoplankton abundance, downstream stations have the greatest abundances. So, the results suggest that downstream stations are richer in phytoplankton which structure differs from that in upper stations.

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Introduction

Phytoplankton in aquatic environments is an important resource due to maintaining of the food chain and consequently the maintenance of the ecosystem functioning. Sterner and Elser (2002) and Twiss et al. (2010) reported that suspended phytoplankton is highly used in the food chain as a rich source of nitrogen and phosphorus relative to macroalgae, macrophytes and detritus. Phytoplankton studies in Africa, particularly in rivers, still very poor. African potamoplankton is therefore poorly known, whereas Silva et al. (2001, 2005) reported that it is specifically very rich.

Potamophytoplankton is sensitive to physico-chemicals factors, climatic factors and river current, and its study appear necessary if needing it as ecological indicator. The unidirectional current imposes a major constraint on the maintenance of its population. Since water is continually transported in downstream, continuous supply of phytoplankton inoculum is necessary (Reynolds, 2000). Therefore, perennial population is dominated by species which can react rapidly, integrating the short water retention time in the River (Kilham et al., 1986; Reynolds, 2000). Dominance by one or only a few numbers of species may therefore be observed (Quiblier et al., 2008). These species, depending on population structure and control factors, may be used in ecosystem bio-monitoring (Tavassi et al., 2008).

To date, Ouémé River's potamophytoplankton remains little known; while this river is one of the biggest one in West Africa. Its ecosystem comprised of much diversified habitats allowing a rich biological community. In different areas, the river receives various substances (domestic, agricultural, industrial, etc.), which doubtless leads to its enrichment in nitrogenous and phosphorus elements. Phytoplankton in this ecosystem would therefore be very rich and

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diversified. The present study is intended to be a first comprehensive assessment of phytoplankton throughout the Ouémé basin. According to Smayda (1980), the specific composition of the phytoplankton communities, the diversity and dominance of one population in relation to another are all evolving characters and phenomena characterizing succession in the community. The study therefore proposed to evaluate these aspects for the suspended phytoplankton community in Ouémé river basin.

Materials and Methods

Study area and sampling sites: The study was carried out in Ouémé River basin, which is the longest and largest catchment area in Benin. It is long about 510 km and its catchment (Fig. 1) extends between 6°51' and 10°11' north latitude and 1°29' and 3°24' east longitude. It covers an area equivalent to half of Benin territory (i.e. more than 50000 km²).

A total of fifteen stations (Fig. 1, Table 1) were sampled. These are representative of both the River course and its main tributaries (Okpara, Zou, Beffa and Donga rivers). Nine stations were retained on the river. The stations of Affon, Bétérou, Atchakpa-Béthel, Atchakpa-Rejet (wastewater discharge point of the "Sucrerie de Complant du Bénin (SUCOBE)" and Atchakpa-Pompage (water pumping point of SUCOBE) were selected to represent the upper course of the river. The three stations in Atchakpa are also representative of the direct effects of SUCOBE on the Ouémé River. The lower course was represented by stations such as Bétékoukou (Dassa), Zagnanado, Bonou and Agonlon-lowé. The last two stations represented the deltaic zone of the basin (in downstream). Six stations were chosen on the selected tributaries. The Kpassa hydraulic dam and the Kaboua station were representative of Okpara River. Toué and Atchérigbé were retained on Zou River while Vossa (Ouessè) and Donga were chosen respectively on Beffa River and Donga River.

Phytoplankton Sampling and processing: Phytoplankton is sampled monthly at each of the fifteen stations between October 2014 and September 2015. The sampling protocol in great Rivers

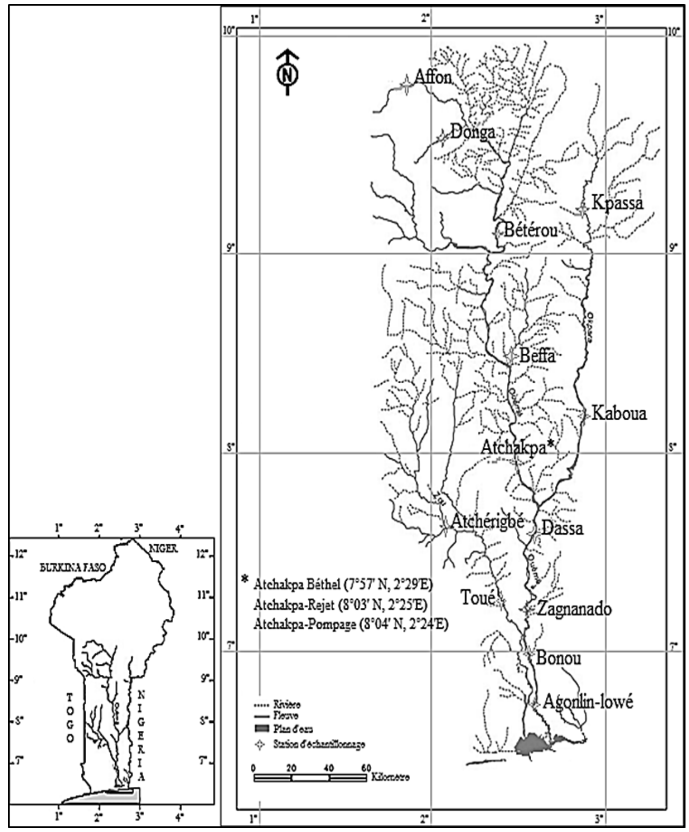

Figure 1. Location of sampling sites.

applicable to the European Water Framework Directive (Laplace-Treyture et al., 2010) has been used. Quantitative samples were taken from the first meter of depth using a Van Dorn horizontal sampler (2 liters). At each station, three samples at three different points (horizontal plane) of 2 L each were taken. They were then mixed and Lugol iodine (8 drops per 100 ml of sample) was added (Druart and Rimet, 2008). The mixture was packaged in polyethylene bottle and allowed to sediment for 24 hours (shadow). Then, it was concentrated by removing water to have 100 ml of sample. Additional fixation was done using 5% formalin (Laplace-Treyture et al., 2010). A complementary sample with a qualitative aim was also taken using 20 µm mesh plankton net.

The samples were processed in a laboratory under light microscope. Phytoplankton species were identified using guides and specific descriptive works such as Prescott (1954), Compère (1974 and 1975), Vanlandingham (1982), Nogueira and Correia (2000), Tsukii (2005), Kinross (2007), Bellinger and Sigee

Table 1. Geographic coordinates of sampling sites.

Stations	Code	River	Latitude	Longitude
Agonlin-Lowé	Ag-L	Ouémé River	6°39'35.2"N	2°28'38.6"E
Bonou	Bon	Ouémé River	6°54'32.5"N	2°26'57.1"E
Zagnanado	Zag	Ouémé River	7°12'50.9"N	2°28'26.4"E
Dassa	Das	Ouémé River	7°37'17.0"N	2°27'59.1"E
Atchakpa-Bethel	Atc-Beth	Ouémé River	8°00'22.9"N	2°22'39.3"E
Atchakpa-Rejet	Atc-R	Ouémé River	8°03'38.1"N	2°22'33.8"E
Atchakpa-Pompage	Atc-P	Ouémé River	8°04'27.0"N	2°22'12.6"E
Bétérou	Bét	Ouémé River	9°11'55.2"N	2°16'04.6"E
Affon	Aff	Ouémé River	9°57'28.6"N	1°51'45.4"E
Kpassa	Kpa	Okpara River	9°16'59.7"N	2°44'13.4"E
Kaboua	Kab	Okpara River	8°10'49.8"N	2°45'05.5"E
Toué	Tou	Zou River	7°12'22.8"N	2°17'23.3"E
Atchérigbé	Atc	Zou River	7°33'44.8"N	2°07'57.7"E
Vossa	Vos	Beffa River	8°29'34.6"N	2°20'27.1"E
Donga	Don	Donga River	9°42'37.7"N	1°56'41.2"E

(2010), Oyadomari (2011) and Simic *et al.* (2014). A four-grid counting cell (Burker turk) was used for cells enumeration for each identified species. The current name of each identified species was searched in AlgaeBase, the global algae information database (Guiry and Guiry, 2016). The systematic classification of AlgaeBase was thus used. Minimum of 400 cells of each identified species were counted. In case of very abundant species (more than 400 cells in 1 ml of sample), they were counted in three consecutive 1 ml sub-samples. Rare species were enumerated in the whole sample volume (Houssou et al., 2016). During counting, only cells with an integral structure were taken into account (Houssou et al., 2015). The phytoplankton density per liter of river water was then estimated using the equation below (Eq1).

Eq1: $D = \frac{1}{6}(\frac{N}{Td} * 100)$

Where D is density of the species per liter of river water. N is the number of cells counted and Td is the rate of sample volume corresponding to N.

Data analysis: The specific composition of phytoplankton in the study area was evaluated and explored with the occurrence frequency (F). The frequency was calculated according to equation (Eq2). It allowed the assessment of species constancy in a given environment (Dajoz 2000). Depending on F value, three groups of species are distinguished: i-) constant species (F ≥ 50%); ii-) accessory species (25% ≤ F <50%) and iii-) incidental species (F <25%). The community structure was studied through the alpha and beta diversity indices. The Shannon Diversity Index (Eq3), the Evenness (Eq4), the Margalef Index (Eq5) and the Dominance Index Y (Eq6) were calculated. Also, spatial similarity of the zooplankton assemblage was studied with Jaccard index (Eq7).

Eq2 (Dajoz, 2000):

$$F=(\mu i \times 100)/\mu T,$$

Eq3 (Shannon and Wiener, 1949):

$$H' = -\sum_{i=1}^{S}(\frac{ni}{N})\log 2\,(\frac{ni}{N})$$

Eq4 (Buzas and Gibson, 1969):

$$Evenness = \frac{e^{H'}}{S}$$

Eq5 (Margalef, 1958):

$$D = \frac{S-1}{\ln N}$$

Eq6:

$$Y = \left(\frac{n}{N}\right) fi$$

Eq7 (Jaccard, 1901):

$$N_C/(N_A+N_B-N_C)$$

Where μ is the number of samples in which species i is present, μT is the total number of samples. S is specific richness, ni is the abundance of species i and N is the total abundance of all species. Fi is the frequency of species i in the samples. NA and NB are respectively the number of species present in the sites A and B to be compared. NC is the number of common species to both sites.

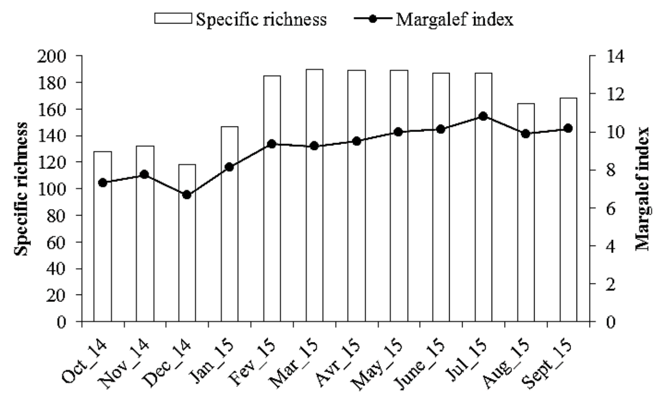

Figure 2. Temporal variation of the specific richness and Margalef index of phytoplankton community in Ouémé basin.

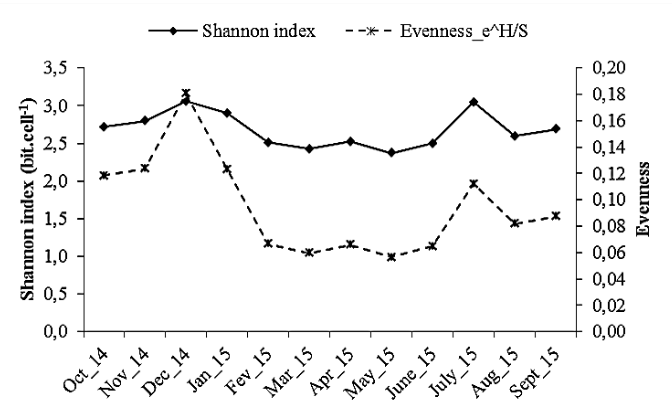

Figure 3. Temporal Variation of Shannon diversity and Evenness index of phytoplankton community in Ouémé basin.

Results

Composition of phytoplankton: The identified phytoplankton community is composed of 208 species (Table 2). They belong to 8 phyla such as Bacillariophyta with 70 species in 39 genera, Chlorophyta with 58 species belonging to 32 genera, Charophyta with 24 species in 10 genera, Euglenophyta with 21 species belong 6 genera, Cyanophyta represented by 18 species in 15 genera, Pyrrophyta with 9 species in 7 genera, Ochrophyta with 5 species in 5 genera and Cryptophytes represented by 3 species belonging to 2 genera.

The species occurrence frequency showed that 137 species among the 208 identified are constant in the area (F≥50%). These include species such as *Microcystis aeruginosa*, *M. flosaquae*, *M. protocystis*, *Anabaenopsis circularis* (Cyanobacteria), *Aulacoseira ambigua*, *A. granulata*, *Gomphonema gracile*, *G. parvulum*, *Cocconeis pellucida*, *Amphora ovalis* (Bacillariophyta), *Euglena gracilis* and *Lepocinclis Oxyuris* (Euglenophyta). A set of 15 species are accessory to the area (25≤F<50). These include *Oscillatoria rubescens*, *G. vibrio*, *Nitzschia rostellata* and *Stephanodiscus* sp.. Fifty-five (55) species were accidental in the basin (F<25%). Among these are marine species such as *Gyrodinium* sp, *Prorocentrum denatatum*, *P. lima*, and *Prorocentrum* sp. (toxic dinoflagellates). These species have been found only in the Ouémé delta.

Alpha and beta diversity of phytoplankton community: The phytoplankton specific richness and Margalef index are presented in Figure 2. Higher richness was observed during low flow (from February to July). The temporal highest richness (190 species) was observed in March. The flood period (from October to December) was that of lower specific richness. The lowest richness (118 species) was observed in December. Margalef's index had same pattern as the specific richness. It varied between 6.7 observed in December and 10.8 in July.

The phytoplankton community was less diversified during the low flow (Fig. 3). The smallest Shannon index (2.4 bit.cell^{-1}) was observed in March and May. In contrast, the community was more diversified in December (3.1 bit.cell^{-1}). The Evenness had same profile as Shannon diversity with values ranged from 0.06 to 0.12.

The Jaccard index (Table 3) showed an important similarity between the phytoplankton communities in all stations (J varying between 0.62 and 1). However, the value of the index was higher between the downstream stations on one hand and between upstream stations (lower limit: Dassa) on the other hand. Value decreases when the communities present in downstream stations are opposite to those present in upstream stations.

Dominant phytoplankton species: Only 14 species including 2 Bacillariophyta, 3 Euglenophyta, 6 Chlorophyta, 2 Charophyta and 1 Cyanophyta largely dominated the phytoplankton population (Table 4). They account for 83.8% of the total phytoplankton abundance in the basin. The two Bacillariophyta

Table 2. Occurrence frequency of identified phytoplankton species in Ouémé River basin.

Phyla	Genera	Species	Occurrence
Cyanophyta	*Anabaena*	*Anabaena oscillarioides*	21.1
	Anabaenopsis	*Anabaenopsis circularis*	58.3
	Aphanocapsa	*Aphanocapsa elegans*	8.9
	Asterocapsa	*Asterocapsa submersa*	100
	Chroococcus	*Chroococcus* sp.	0.6
	Cyanosarcina	*Cyanosarcina thalassia*	7.8
	Dolichospermum	*Dolichospermum spiroides*	55
	Glaucospira	*Glaucospira laxissima*	75.6
	Lyngbya	*Lyngbya* sp.	1.1
	Merismopedia	*Merismopedia glauca*	18.3
	Microcystis	*Microcystis aeruginosa*	100
		Microcystis flosaquae	100
		Microcystis protocystis	100
	Oscillatoria	*Oscillatoria rubescens*	25
		Oscillatoria sp.	92.2
	Stigonema	*Stigonema* sp.	76.7
	Synechocystis	*Synechocystis aquatilis*	98.9
	Tychonema	*Tychonema bornetii*	10
Bacillariophyta	*Achnanthes*	*Achnanthes felinophila*	86.7
	Achnanthidium	*Achnanthidium minutissimum*	66.1
	Amphora	*Amphora ovalis*	83.3
		Amphora sp.	32.8
	Amphipleura	*Amphipleura* sp.	2.2
	Aulacoseira	*Aulacoseira ambigua*	100
		Aulacoseira granulata	100
	Caloneis	*Caloneis undulata*	100
	Catenula	*Catenula* sp.	77.8
	Cocconeis	*Cocconeis pellucida*	96.7
		Cocconeis sp.	33.3
	Coscinodiscus	*Coscinodiscus perforatus*	1.1
		Coscinodiscus radiatus	2.2
		Coscinodiscus sp.	6.7
	Cyclotella	*Cyclotella meneghiniana*	97.2
	Cymbella	*Cymbella lanceolata*	94.4
		Cymbella prostrata	65
		Cymbella sp.	46.7
	Cymatopleura	*Cymatopleura elliptica*	70.6
	Diatoma	*Diatoma* sp.	100
	Entomoneis	*Entomoneis alata*	100
	Eunotia	*Eunotia bilunaris*	100
	Fragilaria	*Fragilaria acus*	23.3
		Fragilaria capucina	16.7
		Fragilaria sp.	100
	Gomphonema	*Gomphonema gracile*	100
		Gomphonema parvulum	100
		Gomphonema sp.	79.4
		Gomphonema vibrio	26.7
	Grammatophora	*Grammatophora* sp.	25
	Gyrosigma	*Gyrosigma acuminatum*	100
		Gyrosigma attenuatum	100
		Gyrosigma sp.	13.3
		Gyrosigma strigilis	8.9
	Hyalodiscus	*Hyalodiscus radiatus*	15
		Hyalodiscus sp.	7.8

Table 2. Continued

Phyla	Genera	Species	Occurrence
	Hyalosynedra	*Hyalosynedra laevigata*	1.1
	Melosira	*Melosira moniliformis*	2.2
	Navicula	*Navicula gregaria*	100
		Navicula peregrina	6.7
	Neidium	*Neidium* sp.	6.7
	Nitzschia	*Nitzschia reversa*	100
		Nitzschia rostellata	38.9
		Nitzschia sp.	68.3
		Nitzschia paradoxa	100
	Parlibellus	*Parlibellus protractoides*	2.2
	Placoneis	*Placoneis constans*	11.1
		Placoneis gastrum	100
	Pleurosigma	*Pleurosigma obscurum*	100
	Pinnularia	*Pinnularia gibba*	10.6
		Pinnularia cardinalis var.	100
		Pinnularia sp.	100
		Pinnularia tabellaria	13.3
	Pseudo-nitzschia	*Pseudo-nitzschia seriata*	2.8
	Rhizosolenia	*Rhizosolenia setigera*	2.2
	Sellaphora	*Sellaphora pupula*	19.4
	Stephanodiscus	*Stephanodiscus alpinus*	100
		Stephanodiscus hantzschii	100
		Stephanodiscus sp.	39.4
	Surirella	*Surirella alata*	100
		Surirella elegans	93.9
		Surirella capronii	100
		Surirella linearis	92.8
		Surirella robusta	100
	Synedra	*Synedra superba*	11.1
	Tabellaria	*Tabellaria flocculosa*	8.3
		Tabellaria sp.	10
	Thalassiosira	*Thalassiosira* sp.	57.8
	Ulnaria	*Ulnaria ulna*	95.6
	Urosolenia	*Urosolenia eriensis*	8.3
Euglénophyta	*Euglenaria*	*Euglenaria anabaena*	8.3
	Euglena	*Euglena gracilis*	100
		Euglena sp.	6.7
	Lepocinclis	*Lepocinclis acus var. longissima*	100
		Lepocinclis oxyuris	96.7
		Lepocinclis sp.	27.2
	Phacus	*Phacus helikoides*	100
		Phacus longicauda	88.9
		Phacus longicauda var. torta	100
		Phacus orbicularis	93.3
		Phacus undulatus	75
	Strombomonas	*Strombomonas acuminata*	100
		Strombomonas confortii	100
		Strombomonas ferrazii	100
		Strombomonas fluviatilis	100
		Strombomonas rotunda	6.7
		Strombomonas scabra	9.4
		Strombomonas verrucosa	100
		Strombomonas verrucosa var.	86.7
	Trachelomonas	*Trachelomonas acanthophora*	13.3
		Trachelomonas sp.	25

Table 2. Continued

Phyla	Genera	Species	Occurrence
Charophyta	*Chlorokybus*	*Chlorokybus* sp.	7.8
	Closterium	*Closterium acerosum*	23.3
		Closterium acerosum var.	100
		Closterium braunii	72.2
		Closterium gracile	100
		Closterium parvulum	100
		Closterium setaceum	54.4
		Closterium tumidulum	23.3
	Cosmarium	*Cosmarium botrytis*	95
		Cosmarium contractum	92.8
		Cosmarium quinarium	2.2
		Cosmarium reniforme	85
		Cosmarium sp.	87.8
	Euastrum	*Euastrum ansatum*	65
	Gonatozygon	*Gonatozygon brebissonii*	2.2
	Klebsormidium	*Klebsormidium* sp.	68.3
	Micrasterias	*Micrasterias fimbriata*	4.4
	Pleurotaenium	*Pleurotaenium ehrenbergii*	2.2
	Staurastrum	*Staurastrum anatinum*	100
		Staurastrum leptocladum f.	100
		Staurastrum longipes	100
		Staurastrum natator	100
		Staurastrum paradoxum var.	100
	Staurodesmus	*Staurodesmus glaber*	100
Chlorophyta	*Actinastrum*	*Actinastrum hantzschii var.*	100
		Actinastrum hantzschii var.	100
	Acutodesmus	*Acutodesmus acuminatus*	100
	Ankistrodesmus	*Ankistrodesmus densus*	100
		Ankistrodesmus falcatus	100
		Ankistrodesmus fusiformis	100
	Chlorogonium	*Chlorogonium sp*	10
	Chodatella	*Chodatella quadriseta*	4.4
	Characium	*Characium oviforme*	26.7
	Cladophora	*Cladophora* sp.	100
	Coelastrum	*Coelastrum astroideum*	100
	Crucigeniella	*Crucigeniella apiculata*	86.7
	Crucigenia	*Crucigenia* sp.	31.7
	Desmodesmus	*Desmodesmus abundans*	100
		Desmodesmus armatus var.	100
		Desmodesmus communis	100
		Desmodesmus intermedius	100
		Desmodesmus intermedius var.	100
		Desmodesmus magnus	100
		Desmodesmus maximus	100
		Desmodesmus opoliensis	16.7
		Desmodesmus opoliensis var.	83.3
	Dicloster	*Dicloster acuatus*	83.3
	Eudorina	*Eudorina carteri*	100
		Eudorina sp.	78.3
	Eremosphaera	*Eremosphaera* sp.	1.1
		Eremosphaera viridis	2.2
	Lacunastrum	*Lacunastrum gracillimum*	23.3
	Lagerheimia	*Lagerheimia* sp.	4.4
	Micractinium	*Micractinium bornhemiense*	100
	Monactinus	*Monactinus simplex var.*	92.8
		Monactinus simplex var. sturmii	100

Table 2. Continued

Phyla	Genera	Species	Occurrence
Chlorophyta	*Neospongiococcum*	*Neospongiococcum* sp.	56.7
	Pachycladella	*Pachycladella zatoriensis*	70
	Pectinodesmus	*Pectinodesmus javanensis*	100
	Pediastrum	*Pediastrum angulosum*	100
		Pediastrum boryanum	100
		Pediastrum duplex	100
		Pediastrum kawraiskyi	76.7
		Pediastrum simplex var.	100
		Pediastrum simplex var.	100
	Quadrigula	*Quadrigula lacustris*	53.3
	Scenedesmus	*Scenedesmus quadricaudata var.*	85
		Scenedesmus obtusus	100
		Scenedesmus tropicus	100
		Selenastrum gracile	100
	Stauridium	*Stauridium privum*	86.1
	Stigeoclonium	*Stigeoclonium aestivale*	100
	Tetradesmus	*Tetradesmus bernardii*	93.3
		Tetradesmus obliquus	66.1
	Tetrastrum	*Tetrastrum heteracanthum*	16.7
	Tetraëdron	*Tetraëdron incus*	62.2
		Tetraëdron gracile	91.7
		Tetraëdron triangulare	53.9
		Tetraëdron trigonum	54.4
	Tetraspora	*Tetraspora* sp.	100
	Treubaria	*Treubaria quadrispina*	66.7
	Volvox	*Volvox aureus*	46.7
Pyrrophyta	*Ceratium*	*Ceratium carolinianum*	70
	Gyrodinium	*Gyrodinium* sp.	5
	Peridiniopsis	*Peridiniopsis quadridens*	83.3
	Peridinium	*Peridinium bipes*	65
	Prorocentrum	*Prorocentrum denatatum*	7.8
		Prorocentrum lima	2.8
		Prorocentrum sp.	1.1
	Pyrocystis	*Pyrocystis* sp.	75
	Scrippsiella	*Scrippsiella trochoidea*	43.3
Ochrophyta	*Centritractus*	*Centritractus africanus*	40
	Dinobryon	*Dinobryon sertularia*	92.8
	Gonyostomum	*Gonyostomum* sp.	66.7
	Tribonema	*Tribonema* sp.	75
	Vaucheria	*Vaucheria* sp.	100
Cryptophyta	*Campylomonas*	*Campylomonas* sp.	94.4
	Cryptomonas	*Cryptomonas ovata*	88.9
		Cryptomonas sp.	86.7

species (*A. granulate* and *A. ambigua*) occupy respectively 40.17% and 6.28% of the total population (i.e. 46.45% for both species). *Euglena gracilis* (Euglenophyta) was the second most dominant species (15.91%). The dominance index *Y* evolved according to species relative abundance. It varied between 0.40 for the most abundant species (*A. granulata*) and 0.01 for the least abundant species (*Acutodesmus acuminatus*). The 14 species have a dominance of 0.83 out of a total of 1 for the identified 208 species.

Discussion

The phytoplankton community recorded in Ouémé basin is composed of 208 species. This specific

Table 3. Jaccard similarity between the phytoplankton communities of Ouémé River basin

	Ag-L	Bon	Zag	Tou	Atc	Das	Atc-Béth	Atc-R	Atc-P	Kab	Vos	Kpa	Bét	Don	Aff
Ag-L															
Bon	0.967														
Zag	0.846	0.867													
Tou	0.764	0.783	0.893												
Atc	0.764	0.783	0.893	1											
Das	0.726	0.744	0.858	0.845	0.845										
Atc-Béth	0.692	0.709	0.818	0.825	0.825	0.954									
Atc-R	0.692	0.709	0.818	0.825	0.825	0.954	1								
Atc-P	0.692	0.709	0.808	0.814	0.814	0.941	0.973	0.986							
Kab	0.649	0.665	0.851	0.74	0.74	0.857	0.898	0.898	0.911						
Vos	0.668	0.685	0.79	0.784	0.784	0.921	0.965	0.965	0.965	0.916					
Kpa	0.62	0.635	0.733	0.756	0.756	0.879	0.909	0.909	0.909	0.985	0.914				
Bét	0.683	0.7	0.807	0.824	0.824	0.94	0.986	0.986	0.986	0.91	0.979	0.908			
Don	0.63	0.645	0.744	0.779	0.779	0.88	0.923	0.923	0.923	0.834	0.915	0.857	0.936		
Aff	0.683	0.7	0.807	0.813	0.813	0.94	0.986	0.986	0.972	0.91	0.979	0.908	1	0.936	

Sampling sites codes are same as in Table 1

Table 4. List of dominant phytoplankton species in Ouémé basin.

Species		**Mean abundance ($x10^4$.cell.L^{-1})**	**Relative abundance (%)**	**Dominance *Y***
Aulacoseira granulata	Bacil	52.82	40.17	0.40
Euglena gracilis	Eug	20.92	15.91	0.16
Aulacoseira ambigua	Bacil	8.25	6.28	0.06
Lepocinclis oxyuris	Eug	5.21	3.96	0.04
Pediastrum duplex	Chlo	3.16	2.40	0.02
Pediastrum angulosum	Chlo	2.94	2.24	0.02
Desmodesmus intermedius var. balatonicus	Chlo	2.85	2.17	0.02
Staurastrum leptocladum cf. africanum	Charo	2.76	2.10	0.02
Microcystis aeruginosa	Cyano	2.56	1.94	0.02
Desmodesmus intermedius	Chlo	1.99	1.51	0.02
Ankistrodesmus densus	Chlo	1.95	1.48	0.01
Cosmarium botrytis	Charo	1.84	1.40	0.01
Phacus longicauda	Eug	1.53	1.16	0.01
Acutodesmus acuminatus	Chlo	1.39	1.06	0.01
Total			**83.77**	**0.83**

richness is more or less stable, showing the ecological importance of this ecosystem. The numerous agro-ecological, industrial and residential areas crossed by the Ouémé river and its tributaries justify this specific richness. Good mineralization in water due to exogenous inputs, allows many species survival and multiplication in the environment.

The observed specific richness is above that reported (89 species) on the Kwa River in Nigeria (Victor et al., 2013) and 192 species on the coastal river in Ivory Coast (Niamien-Ebrottié et al., 2013). It is also superior to the specific phytoplankton richness (149 species) observed in the subtropical river of the lower Iguaçu in Brazil (Perbiche-Neves et al., 2011). It is below the 265 species of phytoplankton identified in the Australian "Daly" tropical river (Townsend et al., 2012). Geographical differences as well as the various levels of anthropization perfectly explain the deviations from these rivers. Albert (2010) reported that a species distribution reflected in its geographical space (longitude, latitude), its ecological niche defined in environmental space (climate, soil, resource). So even in the absence of a significant difference in climate, soil and resources in the environment are important factors to the biodiversity composition. Compared to African lakes, the phytoplankton richness observed in the Ouémé basin is above the 39 species identified in Hlan Lake (Houssou et al., 2016) and 51 species in Azili Lake in Benin (Houssou et al., 2015); these two lakes being strongly influenced by the overflows of Ouémé River. The richness of 111 species of Lake Guiers in Senegal (Ngansoumana, 2006) is also smaller than that of Ouémé.

The phytoplankton community in Ouémé basin was during low flow less diversified than during the flood period. The low flow period was that during which phytoplankton is greatly multiplied. This followed the reduction or even the cancellation of the river flow. Weak nutrient diluted associated with high sun exposure have been major factors which increased phytoplankton development. All species have experienced significant population growth which has raised the specific richness. Therefore, rarest species are sampled. Margalef's specific index confirms the profile observed in the specific richness of the basin. The Shannon index and evenness indicated a relatively good diversification of the phytoplankton community (Chen et al., 1994; Sun et al., 2004). However, few species number is dominant during low flow season. This confirms the high mineralization during this season.

Regarding the dominance, diatom *A. granulata* was more predominant (>40% of the population). This fact confirms observations in which diatoms are dominant in terms of abundance in tropical rivers with a predominance of *A. granulata* and other species of the same genera (Hötzel and Croome, 1996; Decy et al., 2017). According to Reynolds (2000) and Decy et al. (2017), these diatoms are typically of the R strategy. They are able to withstand the nutritional variability associated with variations in water flows and able in achieving net growth within short time imposed by downstream transport. This justifies the dominance of the species even in upstream stations where the River current is more or less continuous throughout the year. Kilham et al. (1986) qualified species of the genus *Aulacoseira* as species adapted to low light conditions.

Chlorophycea species such as those of the genus *Ankistrodesmus*, *Desmodesmus* and *Pediastrum* were also included in the dominant species. This group of species could become predominant in the case of good light penetration in the River (Zalocar de Domitrovic et al., 2014). *Euglena gracilis* and *Lepocinclis oxyuris* were also dominant. These two species are known for their selectivity of eutrophic environment, the anthropic impact in the basin then explains their abundance.

As regards the similarity between phytoplankton communities in the different sampling stations, a horizontal stratification was observed. The community structure in the three stations in the delta area is similar and clearly differs from all other stations. This confirms the upstream-downstream gradient of mineralization in the basin. In addition to direct exogenous inputs, these stations also receive all substance or particle that is transported by the current making nutrients available for habitats variability in the area. It is also observed that community present in the stations from Dassa to Affon and then on Beffa and Okpara rivers are form equivalent.

Conclusion

The floating phytoplankton assemblage in the Ouémé basin is composed of 208 species grouped into 8 phyla: Bacillariophyta, Chlorophyta, Charophyta, Euglenophyta, Cyanophyta, Pyrrophyta, Ochrophyta and Cryptophyta. The population is relatively well diversified with lowest diversity during low flow. Fourteen (14) species are dominant with more than 83% of the total phytoplankton population. *A. granulata* is the most predominant species. Other species such as *E. gracilis*, *A. ambigua* and *L. oxyuris* are also strongly represented. It was also observed an ecological difference between Ouémé delta and all other parts in the basin.

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