



Composition of the Phytoplankton Population of the Ouladine Lagoon South of the City of Grand-Bassam

KOFFI KOMOE¹, N'GUESSAN ROMÉO LOZO^{1*}, ESTELLE SÉVÉRINE KONAN²

¹Félix-Houphouët-Boigny University, Laboratory of Natural Environments and Conservation of Biodiversity, UFR Biosciences, 22 BP 582 Abidjan, Côte d'Ivoire; ²Oceanological Research Center, Abidjan, Côte d'Ivoire.

Abstract | The Ouladine lagoon of Grand-Bassam is subject to a number of pressures due to urbanisation, particularly sand extraction, which is damaging its biodiversity. The aim of this study is to contribute to our knowledge of phytoplankton in the Ouladine lagoon. For this purpose, phytoplankton samples were collected using a 20 µm mesh plankton net during the period from January to June 2017 at three stations (named as ST1, ST2 and ST3). An Olympus CKX 41 photonic microscope equipped with a digital camera was used to observe and photograph various phytoplankton taxa. These observations enabled 76 taxa to be inventoried, divided into four phyla. The phytoplankton distribution revealed a dominance of Heterokontophyta with 36 taxa or 47.4%, followed by Cyanoprokaryota (20 taxa or 26.3%), Chlorophyta (13 taxa or 17.1%) and finally 07 Euglenophyta, or 9.2%. Out of 76 taxa, 07 are reported for the first time in Côte d'Ivoire and are therefore new to the country. We have observed and concluded that the distribution of algal species in the Ouladine lagoon is influenced by pH, turbidity, dissolved oxygen, orthophosphate and nitrate levels.

Keywords | Phytoplankton, Physico-chemical parameters, Ouladine lagoon, Grand-bassam, Côte d'Ivoire

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***Correspondence** | N'Guessan Roméo Lozo, Félix-Houphouët-Boigny University, Laboratory of Natural Environments and Conservation of Biodiversity, UFR Biosciences, 22 BP 582 Abidjan, Côte d'Ivoire; **Email:** lozoromeo85@yahoo.fr

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INTRODUCTION

Côte d'Ivoire has a dense hydrographic network that includes a large lagoon system of about 1200 km² extending from east to west parallel to the shore of the Gulf of Guinea for nearly 300 km (Durand and Chantraine, 1982). The lagoons are brackish environments that are areas of high biological productivity. With their mangroves, these environments are essential to the life cycle of many species of fish, molluscs, crustaceans and migratory birds. However, their geomorphological characteristics mean that these stretches of water are often confined and poorly renewed. These ecosystems are therefore very fragile, and their balance can be rapidly altered under the influence of natural or man-made factors (Amanieu, 1994). In order to preserving the biodiversity of this lagoon system, a number of studies have been carried out on its biological

and ecological components, including phytoplankton Carpentier (1982), Iltis (1984), Adou (1999) and Komoe (2010). According to Feldman (1963), phytoplankton are all plants, generally microscopic, that live freely in water. Their use as biological indicators of water quality has become commonplace in environmental management (Iltis, 1980). Algae are considered to be hydrobiological elements of vital importance in an aquatic biotope and form the basis of the biological cycle in water. However, their presence in the aquatic environment is conditioned by the physical and chemical parameters of that environment (Reynolds, 1998). This lagoon, in this state of disturbance, has not been the subject of any previous study, particularly of phytoplankton. The lack of knowledge of this environment justifies the choice and the interest of the present study. The aim of this study is to determine the phytoplankton composition of the Ouladine lagoon in order to contribute

to our knowledge of its phytoplankton diversity and abundance in the country.

MATERIALS AND METHODS

STUDY ENVIRONMENT

The Ouladine lagoon is bordered by swamp forests with mangroves (Figure 1) and bamboo (Delor *et al.*, 1992). It is located in the southern part of the town of Gand Bassam and communicates with the Comoé River to the east. It is separated from the Atlantic Ocean by a narrow strip of coastline or beach. Located between 5°11' and 5°13' north latitude and 3°43 and 3°50 west longitude, this water covers an area of approximately 4.35 km² (Varlet, 1978). Three sampling stations (S1, S2 and S3) at different locations in the lagoon were chosen for this study.

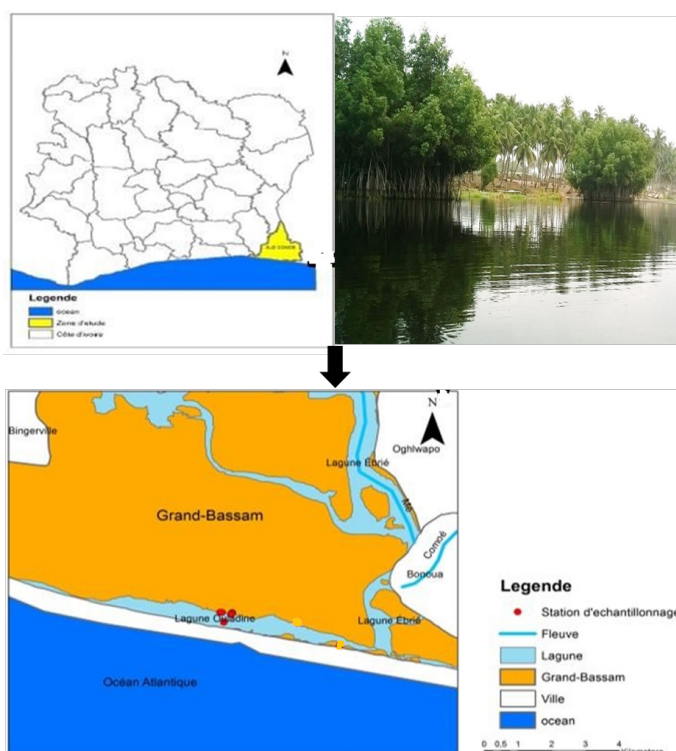


Figure 1: Location of the Ouladine lagoon with sampling stations.

PHYSICO-CHEMICAL PARAMETERS

Physico-chemical parameters (temperature, pH, conductivity, dissolved oxygen, salinity) were measured in the first 50 cm of water. The measurements were carried out in situ. For transparency, the Secchi disc was immersed

in the water until it disappeared completely. Using a graduated wire, it was slowly raised until it reappeared, and the thickness of the euphotic zone was determined from the indication on the graduated wire. Nutrient salts were measured in the C.R.O. chemistry laboratory. Water samples for chemical parameter analysis were taken from 50 cm below the water surface and collected in 1-litre plastic bottles, then stored in a cooler. The analyses were then carried out in the laboratory, and the various concentrations were determined using a JASCO UV spectrophotometer. The principle of measurement is based on Beer-Lambert's law, which indicates the proportionality of the optical density with the thickness of the solution (sample analysed) and the concentration of the chemical element sought.

PHYTOPLANKTON SAMPLING AND IDENTIFICATION

Phytoplankton samples were collected using a plankton net with a mesh size of 20 μm during the period from January to June 2017. Sampling involved filtering five 10-litre buckets of water through the plankton net. Samples collected in the pillboxes were fixed on site with a formaldehyde solution at the final concentration of 5%. An Olympus CKX41 photonic microscope with a 40x objective was used to observe the various samples taken. The various phytoplankton species were identified on the basis of determination and from various documents: [Iltis \(1980\)](#), [Adou \(1999\)](#), [Komoé \(2010\)](#), [Seu-Anoï \(2012\)](#), [Kouassi \(2013\)](#), [Konan \(2014\)](#) and [Lozo \(2016\)](#). Species descriptions will follow the classification established by [Van den Hoek *et al.* \(1995\)](#).

RESULTS AND DISCUSSION

PHYSICO-CHEMICAL PARAMETERS

The values of physico-chemical parameters recorded during sampling of phytoplankton taxa at stations in Ouladine lagoon are given in [Table 1](#).

For salinity and conductivity, the lowest values were observed at stations 2 and 3. Indeed, station 2 and station 3, which record the lowest salinity levels, are the closest to the mouth of the Comoé river. The low salinity values could be due to the phenomenon of dilution of the water in the Ouladine lagoon by the Comoé river and rainwater (Dufour and Durand, 1982). Our results are in line with those

Table 1: Average values of physico-chemical water parameters recorded in the Ouladine lagoon from the three stations from January to June 2017.

	Temp (°C)	Salinité (psu)	pH	Oxi (mg/l)	Cond (µs/cm)	NO ₃ ⁻ (mg/l)	PO ₄ ³⁻ (mg/l)	Turb (NTU)
Station 1	27.74±0.91	12.52±0.87	6.72±2.12	5.64±0.85	17.97±1.95	0.12±0.09	0.65±0.30	0.29±0.14
Station 2	27.18±1.01	1.8±0.91	6.71±2.07	1.92±0.25	8.58±2.72	2.14±0.47	2.64±0.83	0.28±0.11
Station 3	27.39±0.95	0.95±0.97	6.91±1.98	0.98±0.31	3±1.68	2.36±0.82	2.52±0.71	0.61±0.28

obtained by Komoé (2010), who found low salinity in the waters of the Grand-Lahou lagoon complex during the rainy season. The relative thermal stability observed from one station to another is thought to be due to the shallow depth of the Ouladine lagoon (3 m on average) and its strong hydrodynamics, thus reflecting the homogeneity of the waters of Dufour (1984). Nutrient salts (NO_3^- et PO_4^{3-}) are relatively low in the environment. This would seem to be linked to the period of the main rainy season (April to June) during which sampling took place. During the Comoé river flood season, a number of organic wastes are drained by the river, rainwater and run-off into the lagoon. But these elements only decompose in the dry season to release nutrient salts.

PHYTOPLANKTON POPULATION

A total of 76 species of microalgae were inventoried in the course of this study. They are divided into 39 genera, 22 families, 9 orders, 5 classes and 4 phyla (Table 2). The Heterokontophyta phylum is the most diverse with 36 taxa, or 47.4% of the taxa collected. It is followed, respectively by the Cyanoprokaryota phylum with 20 taxa (or 26.3%) and the Chlorophyta phylum with 13 taxa (or 17.1%). The Euglenophyta are the least present with only 7 species (or 9.2%) (Figure 2).

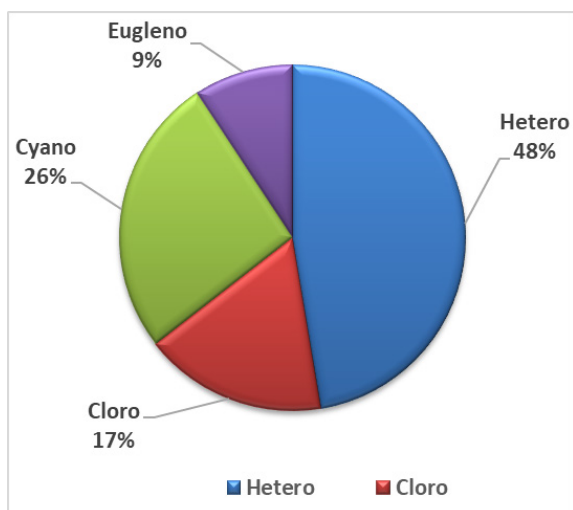


Figure 2: Proportion of different phyla observed from January to June 2027. Chloro: Chlorophyta; Cyano: Cyanoprokaryota; Eugleno: Euglenophyta; Hetero: Heterokontophyta.

Figure 3 shows the distribution of taxa by type of water. At all stations, freshwater taxa dominate, followed by marine taxa and 9 brackish species. Among these taxa, 5 of the phylum Heterokontophyta are both marine and brackish. All the species in the phyla Chlorophyta, Euglenophyta and Cyanoprokaryota are freshwater. Only Heterokontophyta taxa live in all three environments, freshwater, brackish and marine. Station 1 recorded 12 freshwater taxa, 16 marine taxa and 4 brackish taxa. Of these taxa, 21 belong

to the Heterokontophyta, 5 to the Cyanoprokaryota, 4 to the Chlorophyta and 2 to the Euglenophyta. At station 2, there were 23 freshwater taxa, 8 marine and 5 brackish. These included 16 Heterokontophyta, 15 Cyanophyta, 4 Chlorophyta and 1 Euglenophyta. At station 3, 28 freshwater taxa were collected, 07 marine and 05 brackish, including 19 Heterokontophyta, 10 Cyanophyta, 06 Chlorophyta and 05 Euglenophyta. The algae inventoried are present in the stations as follows: 29 taxa for station 1; 33 taxa for station 2 and 37 taxa for station 3 (Table 2). We recorded the discovery of 07 new taxa in the phytoplankton inventoried in Côte d'Ivoire (Figure 4). *Chaetoceros lauderi*, *Melosira italica*, *Pleurosigma angulatum*, *Pleurosigma normanii*, *Closterium pronum*, *Euglena mutabilis* var. *lefevrei* et *Anabaena azollae*.

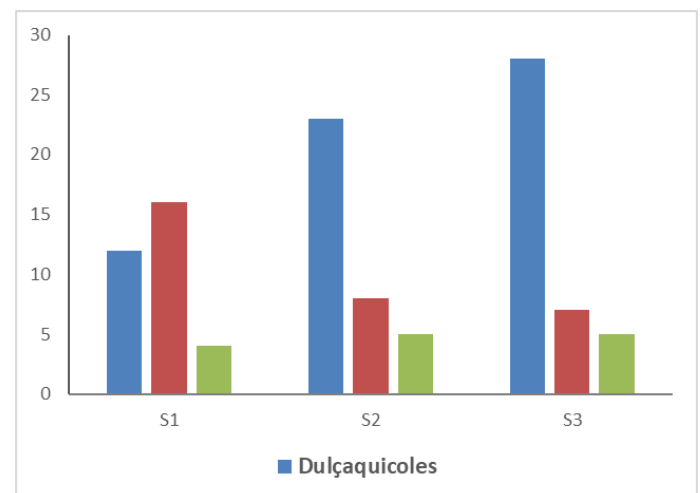


Figure 3: Distribution of taxa by type of water.

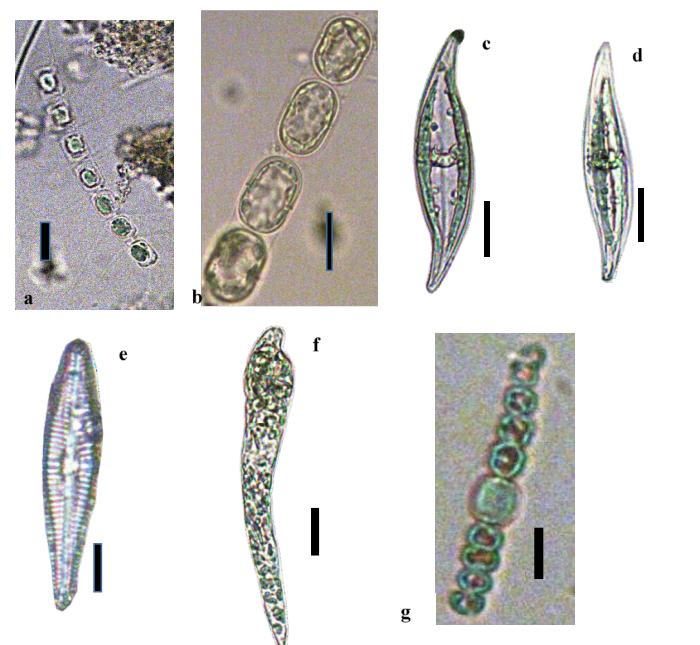


Figure 4: List of taxa inventoried for the first time in Côte d'Ivoire. A, *Chaetoceros lauderi*; b, *Melosira italica*; c, *Pleurosigma angulatum*; d, *Pleurosigma normanii*; e, *Closterium pronum*; f, *Euglena mutabilis* var. *lefevrei*; g, *Anabaena azollae*.

Table 2: List of taxa collected at sites in the Ouladine Lagoon (Côte d'Ivoire) from January to June 2027: x = species present.

Taxons	ST1	ST2	ST3
Embranchement de heterokontophyta			
<i>Achnanthes brevipes</i> var. <i>intermedia</i> (Kützing) Cleve	x		
<i>Achnanthes longipes</i> Agardh	x		
<i>Aulacoseira granulata</i> (Ehrenberg) Simonsen			x
<i>Cerataulus turgidus</i> Ehrenberg	x		
<i>Chaetoceros brevis</i> Schütt	x		
<i>Chaetoceros constrictus</i> Gran	x		
<i>Chaetoceros decipiens</i> Cleve	x		
<i>Chaetoceros lauderi</i> Ralfs in Lauder.		x	x
<i>Chaetoceros similis</i> Cleve	x		x
<i>Chaetoceros subtilis</i> Cleve	x	x	x
<i>Coscinodiscus radiatus</i> Ehrenberg			x
<i>Cyclotella meneghiniana</i> Kütz.	x		
<i>Diploneis smithii</i> (Brébisson in W. Smith) Cleve		x	x
<i>Fragilaria ulna</i> (Nitzsch) Lange-Bert.		x	
<i>Gomphonema affine</i> Kützing	x		x
<i>Gomphonema gracile</i> Ehrenberg			x
<i>Gyrosigma balticum</i> Ehrenberg		x	
<i>Melosira arctica</i> Dickie	x		
<i>Melosira italica</i> (Ehr.) Kützing	x		
<i>Melosira lineata</i> (Dillwyn) Agardh	x		
<i>Melosira moniliformis</i> (O.F. Müller) Agardh	x		
<i>Neidium affine</i> (Ehrbg.) Pfitzer	x		
<i>Nitzschia filiformis</i> (w.Smith) Van Heurck			x
<i>Nitzschia obtusa</i> W. Smith			x
<i>Nitzschia palea</i> (Kützing) Smith		x	x
<i>Petroneis latissima</i> (Gregory) Stickle et Mann in Round <i>et al.</i>		x	x
<i>Pleurosigma angulatum</i> (Quekett) Wm.Smith		x	x
<i>Pleurosigma diverse-striatum</i> Meister		x	
<i>Pleurosigma gracile</i> Hust.	x		
<i>Pleurosigma normanii</i> Ralfs		x	x
<i>Pleurosigma</i> sp	x		
<i>Pleurosira laevis</i> (Ehr.) Compère	x		
<i>Surirella biseriata</i> Bre/J. herb. (S. /Jisériie.)		x	
<i>Terpsinoe intermedia</i> Pantocsek		x	
<i>Terpsinoe musica</i> Ehrenberg	x	x	x
<i>Ulnaria ulna</i> (Nitzsch) Compère			x
Embranchement des Chlorophyta Cavalier-Smit			
<i>Actinastrum hantzschii</i> Lagerheim			x
<i>Achnanthes longipes</i> Agardh	x		

Table continued on next column.....

Taxons	ST1	ST2	ST3
<i>Closterium kuetzingii</i> Brébisson		x	
<i>Closterium pronum</i> Brébisson		x	
<i>Hyalotheca dissiliens</i> Brébisson ex Ralfs	x		
<i>Micractinium pusillum</i> Fresen			x
<i>Oedogonium</i> sp.		x	x
<i>Pediastrum simplex</i> var. <i>sturmii</i> (Reinsch) Wolle			x
<i>Scenedesmus ecornis</i> Ehrenberg	x		
<i>Scenedesmus perforatus</i> var. <i>perforatus</i> fo. <i>Bicaudatus</i> Compère	x		
<i>Scenedesmus quadricauda</i> (Turpin) Brébisson			x
<i>Scenedesmus quadrispina</i> Chod.		x	
<i>Schroederia nitzschoides</i> (G. S. West) Kors.			x
Embranchement des Euglenophyta Pascher			
<i>Euglena anabaena</i> Mainx var. <i>minima</i> Mainx			x
<i>Euglena minima</i> Francé	x		x
<i>Euglena mutabilis</i> var. <i>lefevrei</i> Chadef.		x	
<i>Euglena rubra</i> Hardy	x		
<i>Lepocinclis ovum</i> (Ehrenberg) Lemmermann			x
<i>Phacus longicauda</i> (Ehrenberg) Dujardin var. <i>longicauda</i>			x
<i>Phacus ranula</i> Pochm.			x
Embranchement des Cyanoprocaryota Anagnostidis et Komárek			
<i>Anabaena azollae</i> Strasburger			x
<i>Anabaena constricta</i> (Szafer) Geitler		x	
<i>Anabaena sphaerica</i> Born. et Flah.		x	x
<i>Chroococcus dispersus</i> (Keissler) Lemmermann		x	
<i>Chroococcus minutus</i> (Kütz.) Nag.			x
<i>Chroococcus turgidus</i> (Kütz.) Næg.			x
<i>Lyngbya bourellyana</i> Comp.		x	
<i>Lyngbya major</i> Gomont		x	x
<i>Nostoc entophytum</i> Born. & Flah		x	
<i>Oscillatoria</i> aff. <i>acuminata</i> Gomont	x	x	x
<i>Oscillatoria anguinis</i> (Bory) Gomont		x	x
<i>Oscillatoria</i> cf. <i>annae</i> Van Goor		x	x
<i>Oscillatoria</i> cf. <i>vizagapatensis</i> Rao		x	
<i>Oscillatoria limosa</i> (Dillwyn) Agardh			x
<i>Phormidium</i> cf. <i>simplicissimum</i> (Gomont) Anagnostidis & Komárek	x	x	
<i>Planktothrix compressa</i> (Utermöhl) Anagnostidis & Komárek		x	x
<i>Spirulina gigantea</i> Schmidle		x	
<i>Spirulina laxa</i> G. M. Smith		x	
<i>Spirulina major</i> Kützing ex Gomont	x	x	
<i>Spirulina princeps</i> West & G.S. West		x	
Total 76	29	33	37

There are 04 taxa in the phylum Heterokontophyta and 01 taxon in each of the phyla Euglenophyta, Chlorophyta and Cyanoprokaryota.

The algal flora of the Ouladine lagoon, comprising 76 taxa, can be considered less rich. This low richness could be explained by the short sampling period (3 months for the present study) but also and above all by the invasion of the water body by invasive macrophytes. The presence of macrophytes in the lagoon could lead to a reduction in the penetration of light into the water column, and therefore a reduction in photosynthesis by the algae. These macrophytes would also compete with the algae for nutrients.

The dominance of Heterokontophyta could be explained by the strong influence of oceanic waters, especially at station 1, unlike the Aby lagoon complex which is considered to be a lagoon with a strong continental influence (Metongo, 1985). It is important to stress that in our work, the majority of Heterokontophyta collected are of marine origin. The strong marine influence is thought to be at the root of the development of Heterokontophyta. As for the distribution of taxa according to their nature, we note the presence of 50 freshwater taxa, 23 marine taxa and 09 brackish taxa. All the marine taxa are Heterokontophyta and are observed at station 1 where salinity is highest. Our results are in line with those of Komoé (2010) who obtained Heterokontophyta, the majority of which are marine, in the Grand-Lahou lagoon complex. This could be explained by the high salinity of the water at station 1.

CONCLUSIONS AND RECOMMENDATIONS

The study of algae in the Ouladine lagoon has enabled us to identify the various taxa present in this environment. The micro-algae inventoried during this study number 76 taxa. They are divided into 38 genera, 22 families, 09 orders, 05 classes and 04 phyla. At the end of this work, 07 new taxa were inventoried for the first time in Côte d'Ivoire. These taxa are *Chaetoceros lauderi*, *Melosira italica*, *Pleurosigma angulatum*, *Pleurosigma normanii*, *Closterium pronum*, *Euglena mutabilis* var. *lefevrei* et *Anabaena azollae*. It also emerges that the distribution of the various taxa is influenced by the abiotic parameters of the environment, conditioned by the type of environment.

NOVELTY STATEMENT

This study made it possible to inventory 76 phytoplankton taxa from the Ouladine lagoon. We recorded the discovery of 07 new taxa in the phytoplankton inventoried in Côte d'Ivoire.

AUTHOR'S CONTRIBUTION

Koffi KOMOE conducted this study and contributed to the drafting of the manuscript. Roméo N'Guessan LOZO contributed to the drafting of the manuscript and the analysis and interpretation of the data. Estelle Séverine KONAN helped process the data and revise the manuscript.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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