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Algae from Fresh and Brackish Waters, Côte d'Ivoire

Marie Paulette Adon

Department of Biodiversity and Sustainable Management of Ecosystems, University of Jean Lorougnon Guédé, Daloa, Côte d'Ivoire
Email: adonmariepaulette@gmail.com

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Abstract

The aim of this work is to study the diversity of phytoplanktonic from some fresh and brackish waters. The methodology employed consisted of sampling the organisms using the Van Dorn bottle at the surface (0.5 m) of fresh and sea waters from Container Terminal from San-Pedro Port Area (CTSP) during June and July 2021 and Ebrié Lagoon in June 2023. A total of 324 taxa were collected with 274 taxa for CTSP and 82 taxa for Ebrié Lagoon. The identified phyla were, in order of importance, the Bacillariophyta (151 taxa), Dinophyta (80 taxa), Euglenophyta (34 taxa), Chlorophyta (31 taxa), Chrysophyta (12 taxa), Cyanobacteria (11 taxa), Cryptophyta and Rhodophyta with 2 taxa respectively and Ochrophyta (1 taxon). In the CTSP, the species *Prorocentrum lima* and *Prorocentrum micans* have contributed to the highest number of the taxa during the first mission, but with low contribution during the second mission. At this mission, the contribution of the Dinophyta *Protoperidinium quinquecorne* and the Bacillariophyta *Melosira* spp., *Coscinodiscus nodulifer*, *Thalassionema frauenfeldii* and *Thalassionema nitzschioides* was revealed. The Ebrié Lagoon was characterized by the high contribution of the species *Cyclotella meneghianana* during the sampling mission. As a recommendation, we propose the monitoring in time and space of toxin-producing species and the evaluation of their toxins that could constitute a risk for the fishery, recreational and commercial activities, and the ecosystems studied providing important ecosystem and economic services.

Keywords

Phytoplankton, Diversity, Abidjan, San-Pédro

1. Introduction

Studies of the autecology of different phytoplankton species can help in developing a greater understanding of growth niches, prediction of when blooms may occur and potential control strategies for bloom minimization. The understanding of phytoplankton growth responses to temperature is important due to their regulating role in determining the predominance of certain species [1]. Significant proliferations of certain species occur regularly, especially in spring, sometimes forming "colored waters", the color of the pigments of phytoplankton cells. These efflorescences or "blooms" are natural phenomena, but they are sometimes amplified by significant enrichment of the environment, mainly due to nutrient inputs from rivers and runoff. The species in question are in most cases harmless, but these phenomena sometimes have harmful consequences: indeed, the sudden decrease in available oxygen, created by the decomposition of dead phytoplankton near the bottom, can lead to anoxia, of the environment and therefore to marine animal mortalities [2].

This study, which the aim is to study the diversity of phytoplanktonic from some fresh and brackish waters, is a contribution to the work carried out on the diversity of phytoplanktonic from several Ivorian aquatic ecosystems in which the proliferation of phytoplankton was registered under extreme pollution conditions [3] [4] [5] [6] [7].

2. Material and Methods

2.1. Study Area and Sampling Stations

Both geolocalization and description of stations from the Container Terminal from San-Pedro Port Area (CTSP) were presented in [8]. Concerning Ebrié Lagoon, the geographic coordinates of study stations are presented in Table 1. Sampling Stations P1, P2, P3 and P4 are located in the lagoon between the EOLIS fruit terminal and the National Customs School. Sampling Stations P5, P6, P8, P9 and P10 are located in the lagoon between the ADDOHA lagoon city, the Municipal High School of Attécoubé, Abobo-Doumé Beach and the Abobo-Doumé Lagoon station. Sampling Station P7 is located between Stations P4 and P9.

Table 1. Geographic coordinates of Ebrié Lagoon sites.

Sites	Latitude Nord (ddmns)	Longitude Ouest (ddmns)
P1	5˚19'10.81"	4˚1'48.35"
P2	5˚18'59.30"	4˚1'33.88"
P3	5˚18'55.28"	4˚1'28.39"
P4	5˚18'46.97"	4˚1'17.65"
P5	5˚19'5.09"	4˚1'49.94"
P6	5˚18'56.21"	4˚1'39.34"
P7	5˚18'45.95"	4˚1'28.56"
P8	5˚18'51.02"	4˚1'42.66"
P9	5˚18'42.42"	4˚1'39.83"
P10	5˚18'33.86"	4˚1'33.52"

2.2. Sampling and Study of Phytoplankton Community

The samples used for the study of phytoplankton were obtained 1) from the remaining volume of sample taken using the Van Dorn bottle for the analysis of nutrient salts in Stations S1, S2, S3, S4, S5, S6, S7, S8, S9 and S10 between 8 a.m. and 3 p.m. for the Container Terminal from San-Pedro Port Area (CTSP) and 2) using a plastic bottle of 1-liter capacity at 0.5 m from the lagoon water body in 10 sampling Stations P1, P2, P3, P4, P5, P6, P7, P8, P9 and P10 between 8 a.m. and 3 p.m. The TCSP samples were filtered through a 20 µm diameter plankton net, stored in 100 mL pillboxes and then fixed in 5% formalin for subsequent analysis in the laboratory. In total, 27 samples including 17 samples for the TCSP and 10 samples for the Ebrié Lagoon were collected from the surface water sampling. Observations and counting of organisms were carried out using an Optika-type inverted microscope. The observed taxa were photographed using a Sony Cyber-shot DSC-W800 type camera. The methodology of [9] was used for the preparation of diatoms. The identification of the taxa observed was carried out using general and specific identification books and keys.

Concerning the CTSP samples, the counting of all the organisms was made using the sedimentation cups of volume 3.4 mL, 5 mL, 10 mL, and 25 mL from the inverted microscope according to the method of [10] modified (standard NF EN 15204) by [11]. Replica counts of organisms were carried out on all samples except for samples from Stations S1, S2, S3, S5, S6 and S7 of the second mission. For this mission, 3.4 mL sedimentation cups were used for the samples from Stations S1 and S6, those of 10 mL were used for the samples from Stations S2, S5 and S7. The samples from the Station S3 were counted using the 5 mL volume sedimentation dish. Counting replicas of samples from the first mission were made with 3.4 mL and 5 mL sedimentation cups for samples from Stations S2, S3, S7, S9 and S10. The 5 mL and 10 mL sedimentation cups were used for the samples from Stations S1 and S4. The samples from Stations S5, S6 and S8 were counted using 5 mL and 25 mL sedimentation cups. The sample from the Station S4 of the second mission was counted with 3.4 mL and 25 mL cups. The samples from the Ebrié Lagoon, sub-samples were made in Petri dishes for the observation and counting of the taxa contained in 1 liter of water sample.

The results are expressed in number of individuals per milliliter for the CTSP samples and per liter for the samples from the Ebrié Lagoon.

3. Results and Discussion

3.1. Results

A total of 324 taxa were collected from fresh and brackish waters studied (**Table 2**). The Container Terminal from San-Pedro Port Area (CTSP) was characterized by 274 taxa while Ebrié Lagoon was represented by 82 taxa belonging to Cyanobacteria (11 taxa), Euglenophyta (34 taxa), Chlorophyta (31 taxa), Dinophyta (80 taxa), Cryptophyta (2 taxa), Chrysophyta (12 taxa), Rhodophyta (2 taxa), Ochrophyta (1 taxon) and Bacillariophyta (151 taxa). The genus contributing to

Table 2. Phytoplanktonic list and individuals' number of taxa from Container Terminal from San-Pedro Port Area (CTSP) and Ebrié Lagoon.

	Study stations																										
	CTSP																	Ebrié Lagoon									
	E			C		BL-Z		M		Em	E			C		BL-Z											
Organisms	S1	S2	S3	S4	S7	S5	S6	S8	S9	S10	S1	S2	S3	S4	S7	S5	S6	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Cyanobacteria																											
Aphanocapsa incerta						10	2			2				1													
Chroococcus minutus								2																			
Coelomoron pusillum																									1		
Limnothrix sp.																		1			1	1					
Merismopedia tenuissima			2																								
Microcytis wesenbergii										1																	
Planktothrix agardhii																					1						
Oscillatoria spp.														2								1					
Pseudanabaena catenata					1	3	1					4	12	4	1	3	3										
Pseudanabaena spp.					1										1	1	1										
Plectonema sp.																2											
Euglenophyta																											
Cyclidiopsis acus			3		1																						
Euglena acus							5	1																			
Euglena erhenbergii						1							2		1	4					1				1		
Euglena oxyuris				1			2							2	1	5											
Euglena polymorpha		1	1	1								1	1	1	1	9											
Euglena spp.															1	2											
Lepocinclis ovum						1		2							1	1											
Lepocinclis sp.								1																			
Phacus curvicauda					1		1																				
Phacus glaber							1								1												
Phacus lefevrei			1	1	1				2				2														
Phacus platalea																						1					
Phacus ranula							2																				
Phacus suecicus							2																	1			
Phacus spp.				2									3														
Ploeotia sp.									1	1				2		1											
Strombomonas acuminata			1		1			1								1											
Strombomonas fluviatilis					1		2	1		1																	
Strombomonas girardiana	1	1					2																				
Strombomonas gibberosa						2																					
Strombomonas ovalis										1																	

Continued

Strombomonas spp.			2					1	2				1			1	1										
Trachelomonas armata var. *steinii*																						2					
Trachelomas curta		1																									
Trachelomonas duplex	1																										
Trachelomonas hispida											2											1					
Trachelomonas oblonga	1				2	3	2	3	2	1											4			1			
Trachelomonas planctonica			1	3			8	4	2		2										1		1				
Trachelomonas radiosa			1				2			1				2													
Trachelomonas scabra					1																						
Trachelomonas similis							1																				
Trachelomonas volvocina		1	3	1	2	1	4	12	4	1					4	3					2			8		1	
Trachelomonas volvocinopsis		1	4		2		5	2	1						2	2											
Trachelomonas spp.		1		2		1	2	1				1		1		2			1	1					2		
Chlorophyta																											
Actinastrum hantzschii			2				2									11											
Ankistrodesmus spiralis								1		2																	
Characium angustum		1							1																		
Coelastrum sphaericum																						1					
Cosmarium curcubita															1												
Debarya sp.	1						1	2	2							1											
Dictyosphaerium pulchellum					3		1	2																			
Eremosphaera viridis																						1					
Entromorpha (Ulva) compressa	1															1											
Golenkiena radiata				3		1																					
Korshikoviella sp.	1	1																									
Monoraphidium arcuatum																								1			
Oocystis solitaria		1			2					1										3							1
Pediastrum simplex												1		2													
Scenedesmus acunae																								1	1	2	
Scenedesmus acutiformis																								1			
Scenedesmus bicaudatus					1			2						2										1			
Scenedesmus disciformis																								2			
Scenedesmus obtusus f. *alternans*																		1									
Scenedesmus opoliensis							2																				
Scenedesmus quadricauda																											2
Scenedesmus quadrispina																											1
Spirotaenia kirchneri var. *erythropunctata*															1												

Continued

Teilingia granulata											1													
Tetraedron muticum							2	2																
Tetraedron pentaedricum						1																		
Tetraselmis cordiformis																			2	2				
Tetraselmis sp.																								1
Ulothrix fimbriata																						1		
Ulva flexuosa	4		2	1		6	3		1						1		2							
Ulva spp.	1	1					5						2		1									
Dinophyta																								
Adnatosphaeridium multispinosum																					1			
Anisonema acinus													1											
Amphisolenia sp.			1																					
Amphidinium sp.																1								
Centrodinium spp.			1		1	1	1		1															
Ceratium cf. *balchii*			1																					
Ceratium contortum var. *karstenii*			1	1												1								
Ceratium dens					1																			
Ceratium furca						1																		
Ceratium fusus var. *fusus*				2																				
Ceratium fusus var. *seta*			1																					
Ceratium lunula			3		3	2			1															
Ceratium massiliense			1																					
Ceratium minutum													1											
Ceratium pentagonum			2	4	2	1			1					1										
Ceratium trichoceros			3	4		1			1															
Ceratium tripos var. atlanticum			1		1	1																		
Ceratium spp.			7	2		2							4	2		1								
Cochlodinium strangulatum													1											
Cochlodinium cf. *strangulatum*																1								
Cochlodinium spp.	1											1	1		2		2							
Cordosphaeridium cf. *minimum*																								1
Diplocystis antarctica			1		1							1	12	4		1	1							
Dinophysis caudata			1		2				1															
Ebria spp.	2	1	3	1	3	1										5								
Glenodinium lenticula	1					1	16	1	1				2	4										
Gonyaulax spp.							1						2	1	1	2	2							
Gymnodinium pseudonoctiluca																	1							
Gymnodinium spp.						4		2	3	1	2		1											

Continued

Gyrodinium instriatum													1	1													
Gyrodinium lachryma													1			1											
Gyrodinium spp.			4	1	1											3	1										
Heteraulacus acuminatus						1																					
Heterocapsa triquetra									2																		
Heterodinium leiorhynchus	1	1				3										1											
Heterodinium spp.	2	5	4	3		3			1			2	2	5	3	6	16										
Histioneis sp.																1											
Kenleyia sp.																					1			1			
Kofoidinium spp.	4	3	2	7	2	2	2	1	1		2	3	5	6	2	10	11										
Ornithocercus spp.	1	1			1	7										3											
Ostreopsis sp.	1																1										
Oxytoxum spp.							1	2						4		3											
Peridiniopsis cunningtoni																	1										
Peridinium cinctum	1		1	8	2		14	14	3	1																	
Peridinium umbulatum	1	1			2		1						1														
Peridinium spp.		1	2		1		1	5	1				1	3	1	4	4										
Phalacroma sp.	1															1											
Polykrikos hartmannii																				1	1			3	4	5	
Polykrikos sp.																1											
Pronoctiluca pelagica															1												
Prorocentrum aporum	1																										
Prorocentrum arcuatum				5	5	7		1				2															
Prorocentrum cf. *obtusidens*			1																								
Prorocentrum concavum	2																										
Prorocentrum compressum	1																										
Prorocentrum gracile		2	1	6		17	3			1						5											
Prorocentrum lima						36	4	3																			
Prorocentrum micans		1	6	3	22	23	1	2	11	2			2	2	1	13	6										
Prorocentrum oblongum				3																							
Prorocentrum robustum			1																								
Prorocentrum schillerii						3																					
Prorocentrum triestinum																											1
Prorocentrum spp.	9	6		2	15	10		2	4			3		1	5		3										
Protoperidinium depressum				1		5		4					2														
Protoperidinium minutum	1				1							2															
Protoperidinium oviforme																	1										
Protoperidinium pellucidum	1		1													1											
Protoperidinium pyrophorum	2	1		1	2			2				2	1		1	3	5										
Protoperidinium quinquecorne			5		3						4	18	7	11	3	11	25										

Continued

Protoperidinium spp.							1								1	1	5									
Pseliodinium pirum																1										
Ptychodiscus inflatus						1																				
Ptychodiscus noctiluca						1			1																	
Ptychodiscus spp.			1		1		2																			
Pyrophacus horologium	1			3												2										
Pyrophacus spp.	17	6		4	9		1	1		1	5	11		3		1										
Spatulodinium sp.			1							1																
Torodinium teredo																								1		
Warnowia sp.																				1				1		2
Warnowia virescens	2	1	3	1		16	1						4	2	3	8										
Cryptophyta																										
Cryptomonas ovata																					3					
Cryptomonas sp.			1			3									1						4					
Chrysophyta																										
Chrysococcus rufescens				4	3			1			1	5	2	1		14								1		
Chrysococcus rufescens f. *tripora*			5	5	1			1				1		5	1	3	1									
Chrysococcus triporus			1		1				1			3	1		1	7	1							10		
Chrysococcus spp.					1	1	1							1												
Dinobryon cylindricum var. *divergens*					1																					
Dinobryon sociale					1				1																	
Dinobryon sp.	1				1	1																				
Kephyrion spirale	1				2		1							1	1		1									
Kephyrion spp.	4		2		1	1						1				2										
Ochromonas spp.							2																			
Mallomonas spp.	2				2			2				2				2	2								1	
Pseudokephyrion sp.					3	1																		1		
Rhodophyta																										
Audouinella sp.					1																					
Polysiphonia sp.															1											
Ochrophyta																										
Botrydium granulatum										1																
Bacillariophyta																										
Actinoptychus senarius													1													
Amphiprora alata																1	2									
Amphiprora alata f. *minor*																1										
Amphora coffeaeformis													1													
Amphora proboscidea															1											

Continued

Amphora sp.											1						1										
Asterionella formosa													1														
Asterionella glacialis													1														
Asterionella sp.													1														
Asterolampra cf. *vanheurcki*													1														
Asterolampra marylandica			1									9			1	2	3							1			
Asterolampra sp.															1												
Asteromphalus arachne												1															
Asteromphalus heptactis															1												
Aulacoseira ambigua											1			2													
Aulacoseira distans																	1										
Aulacoseira granulata	3		1		3	1	9	16	4	1				2	1			3	2		4	5		8			
Aulacoseira granulata var. *angustissima*																											4
Aulacoseira granulata var. *angustissima* f. *spiralis*																					1			1			1
Aulacoseira islandica																				1	1						
Auliscus sculptus													1	1													
Auliscus sp.													1														
Auricula complexa												2															
Auricula flabelliformis															1												
Bacillaria paradoxa																								1			
Bacillaria paxillifer														3													
Bacillaria spp.					1						1																
Bacteriastrum hyalinum																	7										
Bellerochea malleus													1														
Bellerochea spp.											1			1	1												
Biddulphia alternans															1				2		2			3	7	3	
Biddulphia aurita													1	1													
Biddulphia aurita var. *obtusa*													1														
Biddulphia mobiliensis																	1								3		
Biddulphia regina																			1					4	2		
Campylodiscus echeneis													1														
Campylodiscus sp.													1														
Catenula exigua sp. nov.																	2										
Cerataulina pelagica													1														
Chaetoceros brevis													1			1											
Chaetoceros decipiens																1											
Chaetoceros didymus													1														
Chaetoceros diversus																1											

Continued

Chaetoceros peruvianus											1			1													
Chaetoceros pseudocurvisetus												1	1		2	1	2										
Chaetoceros spp.											2		1	4													
Climacodium frauenfeldianum													1	6	1												
Climacosphenia elongata		1											1			1	1										
Climacosphenia moniligera													1														
Cocconeis spp.	1	1		5						2				2		2											
Coscinodiscus centralis																			1					1	1	3	
Coscinodiscus concinnus																	2				1				1		
Coscinodiscus divisus																											1
Coscinodiscus granii																1											
Coscinodiscus jonesianus var. *commutatus*													1			1	2									2	
Coscinodiscus nodulifer			2						1		1	1	2	8		34	3										
Coscinodiscus sp.				1	1	1						1			1												
Cyclotella meneghiniana																			2	1	21	5	16	35	2	4	1
Cyclotella sp.		2	3																					1			
Cymbella spp.								1						2													
Detonula pumila													1	2													
Diatoma mesodon																								2			
Diatoma sp.																					1						
Dictyocha fibula														1		2	1										
Distephanus speculum											1	1															
Donkinia recta																1		1	3		1		4	3	5	3	
Encyonema sp.				1																							
Epithemia spp.	1	1	3		2	2	3	1																			
Eunotia minor	2							1		5					1	2	2										
Eunotia serra	1																										
Eunotia sp.		1					1	2														1					
Eunotogramma sp.											1																
Fragilaria striatula																	1										
Fragilaria ulna																1	1										
Fragilria spp.													1			2											
Gomphonema sp.					1																						
Grammatophora cf. *hamulifera*													1														
Grammatophora oceanica											1			1													
Grammatophora oceanica var. *macilenta*																1											
Grammatophora marina														2													1
Grammatophora serpentina														1	1												

Continued

Grammatophora spp.											1																
Guinardia flaccida	3	1	1	2				1		1			1		1	10									2		2
Gyrosygma spp.	2				1					1	4	3	3	4	2	5	1				1						
Helicotheca tamesis												2					1										
Hemiaulus membranaceus													1									1					
Isthmia sp.												1			2												
Lampriscus sp.	2				1	1	4	9																			
Lauderia annulata				1									1														
Leptocylindrus danicus		1					13	1	3															3	2	3	3
Lithodesmium undulatum													1	1													
Mastogloia sp.																						1					1
Mediopyxis helysia												1															
Melosira nummulus																1											
Melosira nummuloides													1														
Melosira varians																					10	1	1	11			
Melosira spp.	2						1				3	5	4	22	1	20											
Meridion circulare																	1										
Navicula distans																2											
Navicula pennata																1											
Navicula pupula																						1					
Navicula sp.																	2										
Neidium sp.																1											
Nitzschia closterium																											1
Nitzschia delicatissima							1	1																			
Nitzschia polaris													1														
Odontella sinensis																	1										
Odontidium mesodon																					1			1			
Pinnularia mesolpepta																								1			
Pinnularia spp.										1	2						2				1						
Plagiogramma staurophorum															1												
Plagiogramma sp.													1														
Plagiotropis lepidoptera																1											
Planktoniella sol													1	1													
Pleurosigma delicatulum											1					1											
Pleurosigma elongata																	1										
Pleurosigma marinum																1											
Pleurosigma simonsenii												1															
Pleurosigma strigosum																1											
Pleurosigma sp.																					1						

Continued

Podosira stelliger																	1										
Podosira sp.													1														
Pseudo-nitzschia fraudulenta																		1				2					
Rhabdonema minutum														1													
Rhizosolenia delicatula																									1		
Rhizosolenia fragilissima																								1			
Rhizosolenia styliformis								1																			
Rhizosolenia sp.																									1		
Skeletonema costatum																							1		1	1	
Stephanopyxis palmeriana																								1			
Stephanopyxis sp.													1	2	1												
Streptotheca spp.	11		2	8	16	5	4		4	2	2		1		1	4										1	
Surirella sp.																1											
Synedra sp.																1											
Tabellaria fenestrata															1												
Terpsinoe musica										1																	
Thalassionema frauenfeldii											3	2	21	30		7	3										
Thalassionema nitzschioides		1	1		2							21	1	1	1	2	4										
Thalassionema synedriforme												10	4			1											
Thalassionema sp.													1			1	1										
Thalassiophysa sp.																					1						
Thalassiosira cf. *pseudonana*													1														
Thalassiosira gravida																		2	1	2	1	2	2	2	6	7	4
Thalassiosira nordenskioldii															1												
Thalassiosira punctigera														1		1	1										
Thalassiosira rotula												1															
Thalassiosira subtilis											1	2					1										
Thalassiosira sp.											1			1		1											
Triceratium pentacrinus						6			2				1	1	2	10											
Tropidoneis sp.													1														
Ulnaria ulna																3	1										
Total: 324	100	49	106	104	147	203	150	118	67	34	47	130	153	182	75	302	150	9	15	12	68	28	25	116	44	37	24

E: Turning site; C: San-Pédro Autonomous Port channel site; BL-Z: Site close to the breakwater and the area to be backfilled as part of the CTSP project; M: Marine site; Em: Site near the mouth and the area intended to accommodate the marine base. S1 to S10 and P1 to P10: study stations.

the high phytoplankton richness were Euglena (5 taxa), Strombomonas (6 taxa), Phacus (7 taxa), Trachelomonas (12 taxa) for Euglenophyta, Scenedesmus with 8 taxa for the Chorophyta, Ceratium (13 taxa), Prorocentrum (13 taxa), Protoperidinium (7 taxa) for Dinophyta, Aulacoseira (6 taxa), Biddulphia (5 taxa), Chaetoceros (7 taxa), Coscinodiscus (7 taxa), Grammatophora (6 taxa), Pleurosigma (6 taxa) and Thalassiosira (7 taxa).

The Stations S1 (100 taxa), S2 (130 taxa) and S3 (106 and 153 taxa) of site E and all stations of sites C and BL-Z except Station S7 of the site C from TCSP of the second mission were characterized by a high number of individuals taxa. The Station S8 of the site M was represented by 118 taxa at the first mission. Concerning the Ebrié Lagoon, the high number of individuals was obtained at the Station P7 with 116 taxa during sampling mission.

During the first mission of June 2021, the species contributed at the highest number in the CTSP were the Dinophyta *Prorocentrum lima* (S5: 36 individuals) and *Prorocentrum micans* (S5: 23 individuals; S7: 22 individuals). The number of the other communities contributed between 1 and 17 individuals. The second mission carried out in July 2021 was characterized by the contribution of the Dinophyta *P. quinquecorne* (S6: 25 individuals) and the Bacillariophyta *Melosira* spp. (S4: 22 individuals; S5: 20 individuals), *Coscinodiscus nodulifer* (S5: 34 individuals), *Thalassionema frauenfeldii* (S3: 21 individuals; S4: 30 individuals), *T. nitzschioides* (S2: 21 individuals). At this mission, the *P. lima* and *P. micans* contribution were lowest in the different stations. In the lagoon Ebrié, the species *Cyclotella meneghiniana* has contributed at the highest number of individuals in the Stations P4 (21 individuals) and P7 (35 individuals) during mission of June 2023.

3.2. Discussion

The study zone was characterized by 324 taxa with 274 taxa for TCSP and 82 Taxa for Ebrié Lagoon. The high number of taxa in the TCSP compared to the Ebrié Lagoon would be due on the one hand to the number of sampling campaigns and on the other hand to their sensibility to environmental conditions as varied as temperature, light, pH, current, grazing by herbivores, oxidizable organic matter, nitrate and phosphate concentrations, dissolved salts, silica content. The low number of taxa in Ebrié Lagoon would be due to its position and many activities carried out in its catchment area. Our results agree with those of [12] who indicated in their work that because of its position, the Ebrié Lagoon in Abidjan records high levels of pollution, particularly in the Banco watershed by the discharges of the countless scrubbers or "laundry washers", liquid and solid effluents from the municipalities of Adjamé, Plateau, Attécoubé and Yopougon leading to an increase in nitrate and phosphate concentrations (organic pollution) which leads to the multiplication of microalgae. These microalgae disappear when the salinity of the water exceeds 15 mg/L.

The contribution of species *P. lima* and *P. micans* in the total number of TCSP taxa in Stations S5 and S7 could be harmful to the human and aquatic (plants and animals) populations due to the toxins they are likely to produce. According to [13] and [14], toxic or otherwise harmful phytoplankton blooms may be increasing in frequency worldwide. Accumulation of phytoplankton toxins in shellfish with subsequent poisoning of humans [15] and fish kills [16] [17] are widely known. *P. lima* is a benthic and epiphytic species that can be phytoplanktonic [18] [19]. According to [20], this species produces a pale-colored resting cyst as part of its life cycle. In contrast, *P. micans* is one of the most common and diversified species in the genus *Prorocentrum*. It is a planktonic species commonly found in neritic and estuarine waters, but it is also found in oceanic environments. It is cosmopolitan in cold temperatures to tropical waters. This species is also known to tolerate very high salinity: population has been reported from hypersaline salt lagoons (>90‰) in the Caribbean islands [19]. Cells are active swimmers [19] [21]. This species forms extensive red tides in many parts of the world [22] [23]. The contribution of *Cyclotella meneghiniana* in the Ebrié Lagoon during the sampling period can be explained by its appearance in warm, nutrient-rich environments as well as low-productivity environments, however, when the salinity of the water does not exceed 15 mg/L.

4. Conclusions

Phytoplankton diversity was relatively high with 324 taxa collected in fresh and brackish waters studied. The CTSP and Ebrié Lagoon studied were characterized by 274 taxa and 82 taxa respectively. The species *Prorocentrum lima* and *Prorocentrum micans* observed in the CTSP and *Cyclotella meneghianana* collected in the Ebrié Lagoon were contributed highly in terms of individual number.

The ecosystems studied provide important ecosystem and economic services, monitoring in time and space of toxin-producing species as well as the evaluation of their toxins that could constitute a risk for the fishery, recreational and commercial activities.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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