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Tidal Variations And Its Impacts On The Abundance And Diversity Of Phytoplankton In The Nyong Estuary Of Cameroon

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***Abstract*— This study presents the results of the impact of tidal variations on the abundance and diversity of phytoplankton in the Nyong estuary of Cameroon. Samples of phytoplankton were collected using a Niskin bottle from five stations designated as Nyong A (NA); Nyong C (NC); Nyong H (NH); Nyong U (NU); Nyong Z (NZ) in March, June, August, December 2014 and January 2015 during high and low tides. Samples were labeled, conserved in 150 cl glass bottles, preserved in 4% Lugol, transported to the laboratory for Research and Development of Microalgae, in Kribi. Samples were examined with an Olympus light microscope with 178 species identified and regrouped into 129 genera, 62 families, 36 orders, 11 classes and 5 divisions. Identification was done using- monographs and research publications. Taxonomic analysis shows that Nyong U was the most diversified at high tide (21%) and at low tide (23%). According to Shannon – Weaver Index, differences in diversity was recorded (Low Tide, H'= 4.96 and High Tide, H'= 4.67). Abundance of different taxonomic divisions decreased from Chlorophyta (35.69%), Cyanophyta (26.36%), Chrysophyta (23.26%), Euglenophyta (9.64%) to Pyrrophyta (5.03%). The Nyong estuary has great potentials for fisheries production owing to its abundant phytoplankton assemblages. Therefore, further research is required on the nutrient input in the study area and their relationship with phytoplankton so as to manage its aquatic ecosystems much better.**

Keywords*— *abundance; diversity index; Nyong estuary; phytoplankton; tidal variation.

INTRODUCTION

Developing countries in the Gulf of Guinea are fighting poverty while increasing the exploitation of natural resources with severe consequences on the environment. To meet this challenge, a project JEAI-RELIFOME of the young researcher's team of the University of Douala in Cameroon associated with IRD, French acronym for International Institute for Research and Development carried out a research in the shallow brackish water of the Nyong estuary.

Brackish water of estuaries constitutes a transitory zone between freshwater and marine water. It has an interface function between land and ocean and plays an important role on biodiversity development according to spatiotemporal variation [1]. Cameroon fishery zone is enriched by river discharge; notwithstanding, there is very little information on Cameroon estuary ecosystem. For quite some time now scientists are interested in algae research because of the importance of microorganisms in many areas like: fuel industry, public health, bioremediation, biological indicators, where their presence, absence, diversity, abundance and distribution are used to determine the health of an aquatic environment [2]. It is on this basis that the JEAI-RELIFOME project considers it a challenge to monitor the Nyong river ecosystem, the most important river in the southern coastal zone of Cameroon with 640 km long and a catchment area of 28 000 km² flowing through Batanga village in the Gulf of Guinea [3]. Nyong river has attracted the attention of many researchers and international agencies because little or no study exits on the downstream section of the river. The mouth of the river Nyong surrounded by swamps and mangrove forests is of great biological wealth, both in quantity and quality. The meso-tidal estuarine environment is often characterized by high turbidity, which generally limits local primary productivity such as phytoplankton

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[4]. The present research aims at evaluating the impact of tidal variations on phytoplankton abundance and diversity at the Nyong estuary inoder to produce a checklist of floristic richness of the river.

I. MATERIAL AND METHODS

Study Area: The Nyong estuary, located between latitudes 2°48' and 4°32' N and longitudes 9°54' and 13°30' E, is a part of the Campo – Nyong estuary system in the Southern part of the Cameroon Coastal zone. Amongst the 14 rivers that flow in the Cameroun Atlantic Ocean, river Nyong is second in importance after river Sanaga. Its downstream runs out through Edea-Douala reserve forest with 466 m^3/s and 12.5 m of altitude at Dehane [3]. The climate is Equato- Guinean with the velocity of the monsoon wind not exceeding 10 km/h. It has a mean annual rainfall of 2694 mm around the Edea-Douala reserve forest and an average temperature of 26.8°C per year [5], [6].

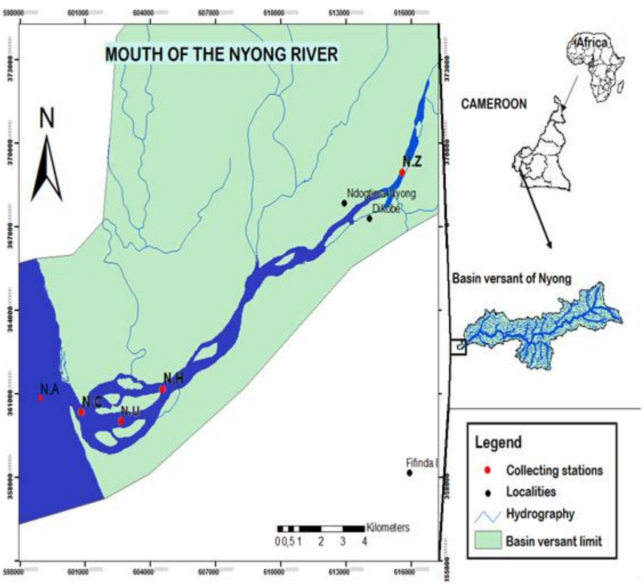

Fig. 1: Location of the study zone

Data collection: The study was carried out between March, June, August, December 2014 and January 2015 during high and low tides to determine spatiotemporal variation of floristic algae in water. These stations were chosen from downstream to upstream of the river to show the biodiversity of the hydro-system. These stations were designated as:

- Nyong A (NA), located at the nautical part of the study area;
- Nyong C (NC), Nyong H (NH) and Nyong U (NU) located at the brackish zone made up of Mangrove Islands. The distance between NC and NA is 1.5 km; NC to NU 1.5 km and NU to NH 2 km;
- Nyong Z (NZ) is located upstream of the study area, in a locality called Dikobe, 10 km from NH.

At each designated station, surface water was collected using a neskin bottle and transferred into a 150cl glass bottle. The algae were preserved in lugol and kept at 4°C, latter transferred to the laboratory for Research and Development of Microalgae at the Institute of Agricultural Research for Development (IRAD) in Kribi. A total of 50 samples were collected at a rate of 25 each per tide.

In the laboratory, two drops were mounted on a glass slide at three different intervals for each sample and observations made using Olympus light microscope of magnification 60X equipped with Malassez cell counting device. Identification and classification of phytoplankton was done using standard monographs and scientific publications including [7], [8], [9], [10], [11], [12], [13], [14], [15].

Data analysis: The density of species were calculated by using the following formula $C° = n \times 100 \times 1000$ [16] (where C^o represents the concentration of cells (unit per ml) of the specie; n is the average number of times that species were observed in the microscope and 100 X 1000 being 10^5, the volume of the observed sample in Malassez's cell.

Phytoplankton diversity or information about specific richness of ecosystem was calculated using Shannon-Weaver (H'), which is line with studies carried out by [17].

Shannon-Weaver formula:

H' = - $\sum_{i=1}^{S} pi \log_2 pi$ or $pi = \frac{Ni}{N}$ and 0 < H' <$\log_2 S$.

Where Ni is a number of individuals of the species i, N represents the total number of the population (individuals of all species) and S the total number of species in the study area.

Species evenness was calculated by using Pielou's evenness which is in line with [18].

Pielou formula:

R = H' / H'max, where H'max = $\log_{(2)}(S)$

R is between 0 and 1

The influence of tidal variation on phytoplankton diversity was evaluated by using a box plots which gave an overview of the spatiotemporal distribution of species. The graphs were plotted by using a statistical software R.3.0. The spatiotemporal variability of floristic data was studied by ANOVA ($P<0.05$). Comparison of abundance and their classification was done using Pearson dispersion test with the variance analysis revealing a significant difference. Secondly, a statistical analysis was done using the software PASS. Variables used for this statistical analysis were the number of family's that appeared in each tide.

II. RESULTS

II.I. PHYTOPLANKTON CHECKLIST IN NYONG ESTUARY

The classification of the phytoplankton into Division, Class, Order, Family, Genus and Species is illustrated in Table 1.

Table I: Phytoplankton of Nyong estuary and their abundance during the study period

Division	Class	Order	Family	Genus	Species	Abundance	Identification catalogues
Chlorophyta	Charophyceae	Charales	Characeae	*Chara*	*Chara sp.*	++	[15]
					Chara vulgaris	++	[7]
	Chlorophyceae	Chaetophorales	Chaetophoraceae	*Stigeoclonium*	*Stigeoclonium aestivale*	++	[13]
		Chlorococcales	Chlorococcaceae	*Tetraedron*	*Tetraedron caudatum*	++	[13]
					Tetraedron gracile	+	[7]
					Tetraedron minimum	++	[7]
					Tetraedron muticum	++	[7]
			Dictyosphaeriaceae	*Botryococcus*	*Botryococcus braunii*	+++	[7]
				Dictyosphaerium	*Dictyosphaerium pulchellum*	++	[7]
			Hydrodictyaceae	*Pediastrum*	*Pediastrum clathratum*	+	[15]
					Pediastrum duplex	++	[7]
				Sorastrum	*Sorastrum spinulosum*	++	[7]
			Micractiniaceae	*Micractinium*	*Micractinium pusillum*	+	[7]
			Oocystaceae	*Chodatella*	*Chodatella quadriseta*	++	[7]
					Chodatella subsalsa	++	[7]
				Eremosphaera	*Eremosphaera gigas*	++	[13]
				Kirchneriella	*Kirchneriella obesa*	+	[7]
				Nephrocytium	*Nephrocytium agardhianum*	++	[7]
				Oocystis	*Oocystis lacustri*	++	[11]
				Selenastrum	*Selenastrum gracile*	+	[11]
			Palmellaceae	*Sphaerocystis*	*Sphaerocystis schroeteri*	+	[11]
			Scenedesmaceae	*Coelastrum*	*Coelastrum cambricu*	++	[7]
					Coelastrum microporum	++	[7]
				Crucigenia	*Crucigenia tetrapedi*	++	[7]
				Scenedesmus	*Scenedesmus acuminatus*	+	[7]
				Tetrastrum	*Tetrastrum heteracanthum*	+	[7]
		Dichotomosiphonales	Dichotomosiphonaceae	*Dichotomosiphon*	*Dichotomosiphon tuberosus*	++	[7]
		Oedogoniales	Oedogoniaceae	*Oedogonium*	*Oedogonium anomalum*	+	[7]
		Siphonocladales	Siphonocladaceae	*Cladophora*	*Cladophora holsatica*	++	[13]

Chlorophyta	Chlorophyceae	Sphaeropléales	Bryopsidophycideae	*Sphaeroplea*	*Sphaeroplea soleirolii*	++	[13]
		Tétrasporales	Tétrasporaceae	*Tétraspora*	*Tetraspora gelatinosa*	++	[13]
		Trentepohliales	Trentepohliaceae	*Trentepohlia*	*Trentepohlia arborum*	++	[7]
		Ulothricales	Ulothricaceae	*Binuclearia*	*Binuclearia eriensis*	++	[7]
				Ulothrix	*Ulothrix bipyrenoidosa*	++	[7]
				Uronema	*Uronema elongatum*	++	[11]
		Ulvales	Ulvaceae	*Schizomeris*	*Schizomeris leibleinii*	++	[11]
		Volvocales	Phacotaceae	*Phacotus*	*Phacotus lenticularis*	++	[7]
			Polyblépharidaceae	*Polyblepharides*	*Polyblepharides fragariiformis*	++	[7]
			Volvocaceae	*Pandorina*	*Pandorina morum*	++	[7]
				Pleodorina	*Pleodorina sphaerica*	++	[7]
				Volvox	*Volvox aureus*	++	[7]
	Prasinophyceae	Pyramimonadales	Pyramimonaceae	*Pyramimonas*	*Pyramimonas acuta*	++	[7]
	Zygophyceae	Desmidiales	Desmidiaceae	*Arthrodesrnus*	*Arthrodesrnus mucronulatus*	++	[11]
				Bambusina	*Bambusina armata*	+	[11]
				Closterium	*Closterium aciculare*	+++	[7]
					Closterium lanceolatum	++	[15]
					Closterium parvulum	++	[7]
				Cosmarium	*Cosmarium binu*	+	[14]
					Cosmarium candianum	+	[7]
					Cosmarium granatum	++	[13]
				Desmidium	*Desmidium baileyi*	+	[7]

				Euastrum	Euastrum glaziovii	++	[13]
					Euastrum sphyroides	+	[7]
				Hyalotheca	Hyalotheca mucosa	+	[7]
				Micrasterias	Micrasterias foliacea	++	[7]
					Micrasterias truncata	+	[7]
				Phymafodocis	Phymatodocis irregulare	+++	[7]
				Pleurotaenium	Pleurotaenium trabecula	++	[7]
				Sphaerozosma	Sphaerozosma laeve	+	[7]
				Staurastrum	Staurastrum leptocladum	++	[7]
					Staurastrum setigerum	++	[7]
				Staurodesmus	Staurodesmus validus	++	[14]
				Xanthidium	Xanthidium subtrilobum	+	[7]
Chlorophyta	Zygophyceae	Zygnématales	Mesotaeniaceae	Gonatozygon	Gonatozygon aculeatum	++	[7]
					Gonatozygon monotaenium	++	[7]
				Mesotaenium	Mesotaenium macrococcum	++	[14]
			Zygnémataceae	Mougeotia	Mougeotia floridana	+	[14]
				Zygnema	Zygnema stellinum	+	[7]
Chrysophyta	Chrysophyceae	Monosigales	Monosigaceae	Sphaeroeca	Sphaeroeca volvox	++	[7]
		Ochromonadales	Dinobryaceae	Dinobryon	Dinobryon sertularia	+	[7]
			Synuraceae	Mallomonas	Mallomonas mirabilis	++	[13]
	Diatomophyceae	Achnanthales	Achnanthaceae	Achnanthes	Achnanthes exiguoides	++	[13]
				Cocconeis	Cocconeis placentula	++	[7]
		Bacillariales	Fragilariaceae	Licmophora	Licmophora ehrenbergii	++	[11]
		Biddulphiales	Chaetoceraceae	Chaetoceros	Chaetoceros muelleri	+	[12]
			Hemidiscaceae	Hemidiscus	Hemidiscus cuneiformis	+	[11]
		Coscinodiscales	Coscinodiscaceae	Coscinodiscus	Coscinodiscus rudolfii	++	[12]
					Coscinodiscus stellaris	+	[11]
				Cyclotella	Cyclotella meneghiniana	+	[12]
					Cyclotella stelligera	++	[8]
				Melosira	Melosira granulata	+++	[7]
				Stephanodiscus	Stephanodiscus astraea	++	[7]
		Diatomales	Diatomaceae	Fragilaria	Fragilaria construens	++	[13]
				Synedra	Synedra ulna	++	[13]
				Tabellaria	Tabellaria flocculosa	++	[8]
		Eunotiales	Eunotiaceae	Eunotia	Eunotia didyma	+	[7]
					Eunotia tschirchiana	+	[7]
		Naviculales	Epithémiaceae	Epithemia	Epithemia zebra	++	[7]
				Rhopalodia	Rhopalodia gibba	++	[11]
			Naviculaceae	Amphora	Amphora ovalis	++	[7]
				Anomoeoneis	Anomoeoneis sphaerophora	++	[9]
				Cymbella	Cymbella turgida	+	[7]
					Cymbella ventricosa	++	[8]
				Denticula	Denticula thermalis	++	[7]
				Diploneis	Diploneis ovalis	++	[9]
				Epithemia	Epithemia turgida	++	[7]
Chrysophyta	Diatomophyceae	Naviculales	Naviculaceae	Gomphonema	Gomphonema acuminatum	+	[11]
					Gomphonema olivaceum	++	[7]
				Mastogloia	Mastogloia smithii	++	[7]
				Navicula	Navicula cryptocephala	+	[12]
				Pinnularia	Pinnularia cardinalis	++	[7]
				Pleurosigma	Pleurosigma directum	+	[11]
				Surirella	Surirella linearis	++	[11]
			Nitzschiaceae	Hantzschia	Hantzschia amphioxys	++	[7]
				Nitzschia	Nitzschia amphibia	++	[13]
					Nitzschia sigma	++	[11]
					Nitzschia tryblionella	++	[7]

					Pseudo-nitzschia pungens	+	[11]
			Surirellaceae	*Cymatopleura*	*Cymatopleura solea*	++	[8]
				Surirella	*Surirella capronii*	++	[7]
		Rhizosoleniales	Campylodiscuceae	*Campylodiscus*	*Campylodiscus noricus*	++	[13]
			Rhizosoleniaceae	*Rhizosolenia*	*Rhizosolenia hebetata*	+	[11]
					Rhizosolenia imbricata	+	[11]
					Rhizosolenia iongiseta	++	[14]
	Xanthophyceae	Mischococcales	Pleurochloridaceae	*Goniochloris*	*Goniochloris gigas*	++	[7]
			Sciadiaceae	*Ophiocytium*	*Ophiocytium cochleare*	+++	[7]
Cyanophyta	Cyanophyceae	Chroococcales	Chroococcaceae	*Aphanothece*	*Aphanothece elabens*	++	[7]
				Chroococcus	*Chroococcus limneticus*	++	[7]
					Chroococcus turgidus	+	[7]
				Coelosphaerium	*Coelosphaerium conferium*	++	[7]
					Coelosphaerium kuetzingianum	++	[13]
				Gomphosphaeria	*Gomphosphaeria aponina*	++	[7]
					Gomphosphaeria naegeliana	++	[7]
				Merismopedia	*Merismopedia elegans*	+++	[7]
				Microcystis	*Microcystis aeruginosa*	+++	[14]
					Microcystis delicatissima	++	[7]
					Microcystis elachista	++	[7]
				Synechococcus	*Synechococcus aeruginosus*	++	[7]
					Synechococcus leopoliensis	++	[7]
				Synechocystis	*Synechocystis aquatilis*	+++	[7]

Cyanophyta	Cyanophyceae	Nostocales	Microchaetaceae	*Microchaete*	*Microchaete investiens*	+	[7]
			Nostocaceae	*Anabaena*	*Anabaena flos-aquae*	+	[15]
					Anabaena spiroides	+	[7]
				Anabaenopsis	*Anabaenopsis arnoldii*	++	[7]
					Anabaenopsis circularis	++	[7]
					Anabaenopsis tanganyikae	+	[7]
				Nostoc	*Nostoc piscinale*	++	[15]
				Raphidiopsis	*Raphidiopsis mediterranea*	++	[7]
			Oscillatoriaceae	*Lyngbya*	*Lyngbya martensiana*	++	[7]
					Lyngbya sp.	+	[15]
				Oscillatoria	*Oscillatoria chalybea*	+	[7]
					Oscillatoria terebriformis	+	[15]
				Spirulina	*Microcoleus lacustris*	++	[7]
					Oscillatoria platensis	+	[7]
			Rivulariaceae	*Calothrix*	*Calothrix brevissima*	++	[7]
					Calothrix scytonemicola	++	[7]
				Gloeotrichia	*Gloeotrichia natans*	++	[7]
					Gloeotrichia pilgeri	++	[7]
				Rivularia	*Rivularia aquatica*	+++	[7]
			Tolypothriceae	*Tolypothrix*	*Tolypothrix sp.*	++	[13]
		Stigonématales	Hapalosiphonaceae	*Hapalosiphon*	*Hapalosiphon sp.*	++	[7]
			Mastigocladuceae	*Mastigocladus*	*Mastigocladus sp.*	++	[7]
			Stigonémataceae	*Scytonema*	*Scytonema sp.*	++	[7]
Euglénophyta	Euglénophyceae	Colaciales	Colaciaceae	*Colacium*	*Colacium cyclopicola*	+++	[14]
		Euglénales	Euglénaceae	*Astasia*	*Astasia torta*	+++	[14]
				Euglena	*Euglena ehrenbergii*	++	[7]
					Euglena viridis	++	[15]
				Lepocinclis	*Lepocinclis ovum*	+	[7]
				Phacus	*Phacus orbicularis*	++	[7]
					Phacus suecicus	++	[7]

Euglénophyta	Euglénophyceae	Euglénales	Euglénaceae	*Strombomonas*	*Strombomonas verrucosa*	++	[7]
				Trachelomonas	*Trachelomonas*	++	[7]

					globularis		
					Trachelomonas hispida	++	[7]
					Trachelomonas lefevrei	++	[7]
	Cryptophyceae	Cryptophytes	Cryptomonadaceae	*Cryptomonas*	*Cryptomonas erosa*	++	[9]
	Dinophyceae	Dinophysiales	Dinophysiaceae	*Dinophysis*	*Dinophysis acuminata*	+	[11]
					Dinophysis caudata	+	[13]
		Gonyaulacales	Gonyaulacaceae	*Gonyaulax*	*Gonyaulax spinifera*	+	[11]
		Noctilucales	Noctilucaceae	*Noctiluca*	*Noctiluca scintillans*	++	[11]
Pyrrophyta		Peridiniales	Calciodinellaceae	*Scrippsiella*	*Scrippsiella trochoidea*	+	[11]
			Ceratiaceae	*Ceratium*	*Ceratium hirundinella*	++	[7]
			Gymnodiniaceae	*Gymnodinium*	*Gymnodinium rofundatum*	++	[7]
			Peridiniaceae	*Peridinium*	*Peridinium cinctum*	++	[7]
					Peridinium pusillum	++	[7]
				Prymnesium	*Prymnesium saltans*	+	[10]
			Protoperidiniaceae	*Protoperidinium*	*Protoperidinium diabolum*	+	[11]
					Protoperidinium excentricum	+	[11]
					Protoperidinium pentagonum	++	[11]

+ : Less abundant 0,00 to 0,99 ; ++ : Abundant 1,00 to 1,99; +++ : More abundant **>**2,00

A total of 178 species, 129 genera, 62 families, 36 order, 11 class, and 5 divisions were observed in the Nyong Estuary during our study period as shown in Table 1. The specific richness of the ecosystem was evaluated by Shannon – Weaver H'= 9.63. This value justifies the diversity of the estuary. The specific abundance of the various divisions decreased from Chloropyta (35.69%), Cyanophyta (26.36%), Chrysophyta (23.26%), Euglenophyta (9.64%) to Pyrrophyta (5.03%). Chlorophyta was dominated by two classes: Chlorophyceae and Zygophyceae. The Principal genera observed in this division were: Closterium (3.9%), Botryococcus (2.45%) and Phymatodocis (2.24%). Cyanophyta was strongly represented by Cyanophyceae. Diatomophyceae (18.68%) was the dorminant class of Chrysophyta division, followed by Xanthophyceae (3.28%) and Chrysophyceae (1.3%). Euglenophyta represented by Euglenophyceae class, was dominated by the Euglenaceae family. Classes of Dinophyceae and Cryptophyceae represented Pyrrophyta with a dominance of one order, Peridiniales. The Pielou Index R = 0.98, showed how close in numbers were species at the different sampling stations. Box plots showed the distribution of central trends and dispersion of Shannon index at each station. Fig. 2 indicates that the median is at the bottom of the box, which implies a skewed distribution towards lower values of the Shannon-Weaver diversity indices at high and low tides. However, there is an exception for both cases at station NH. NH resort to the median highest and seems almost in the middle of the box with symmetry at high tide. The body of the box plots is large and seems identical with the inter-quartile interval between 0.01 and 0.16 at low tide except at NC where the box is smallest compared to others. In the case of high tide, median and inter-quartile values were different for each station; with the same minimal value and the maximal value observed at NU. The graph is showing an outlier upper value at the maximum of box plot at high tide for NA, corresponding index with values of Shannon - Weaver of family Naviculaceae (H '= 0.24) which is above the maximum of Box plot at high tide. When applied to each stations abundance, using ANOVA ($P<0.05$), algae revealed a significant difference between NC and NH for Chrysophyceae at low tide. Shannon – Weaver index showed a difference of diversity according to tidal variations (Low Tide, H'= 4.96 and High Tide, H'= 4.67) with algae composition identified in Low and High Tide seems fairly diversified (Tables 2 and 3).

Division	Class	Order	Family	Genus	Species	% taxa composition
Chlorophyta	4	17	21	45	59	40,13
Chrysophyta	3	13	14	28	35	23,8
Pyrrophyta	2	3	6	6	9	6,12
Cyanophyta	1	3	9	23	34	23,12
Euglénophyta	1	2	2	7	10	6,8
Total	**11**	**38**	**52**	**109**	**147**	**100**

Table 2: Taxonomy of phytoplankton communities at Low Tide

Table 3: Taxonomy of phytoplankton communities at High Tide

Division	Class	Order	Family	Gender	Species	% taxa composition
Chlorophyta	4	15	24	48	55	37,67
Chrysophyta	3	11	18	36	42	28,76
Pyrrophyta	2	5	8	9	11	7,53
Cyanophyta	1	3	7	20	28	19,17
Euglénophyta	1	2	2	6	10	6,84
Total	**11**	**36**	**59**	**119**	**146**	**100**

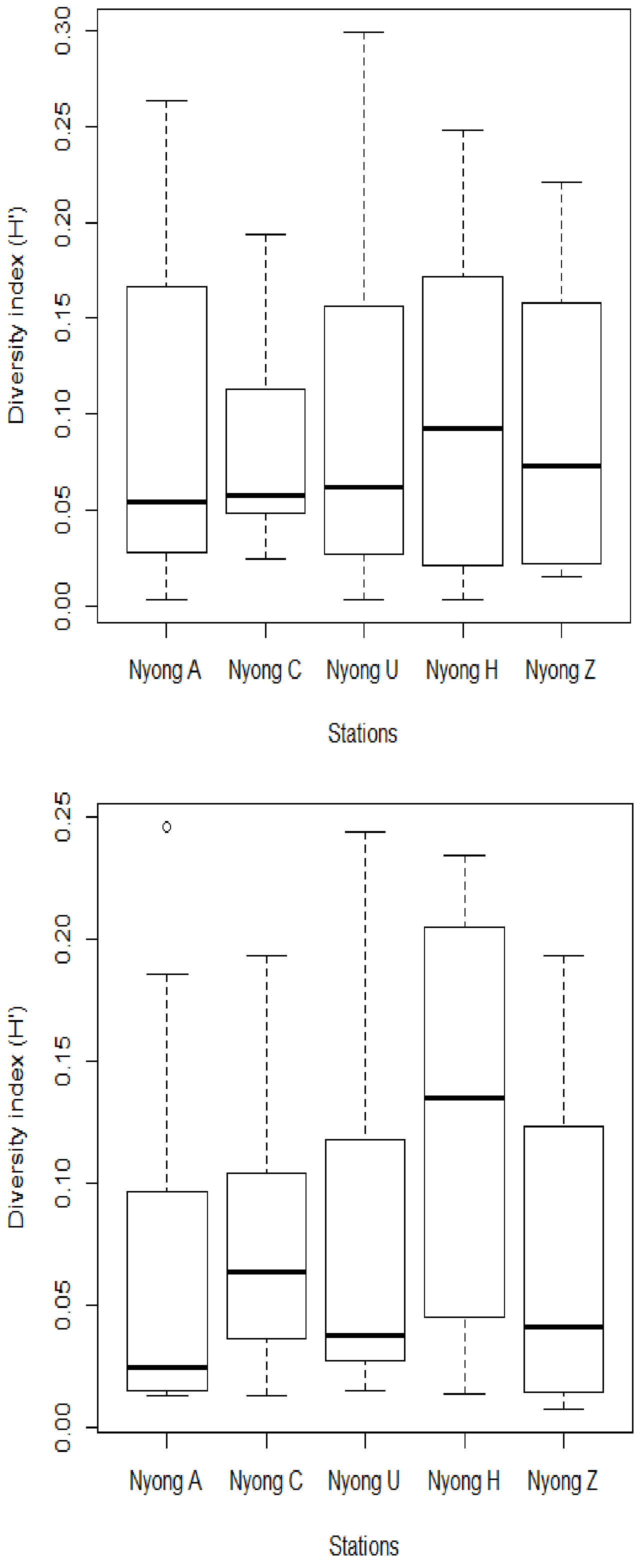

Fig. 2: Spatiotemporal variability of Shannon-Weaver diversity index at Low Tide (left) and at High Tide (right).

The specific abundance of phytoplankton species was recorded in NA at Low Tide (12.64%) than at High Tide 8.27%) as shown in Fig.3a&b. In NA (Fig.3a), the most abundant species was *Microcystis aeruginosa* (5x105cells.l-1) which was absent in NU and NH. This was closely followed by *Botryococcus braunii* (3.91x105cells.l-1) and *Sphaeroeca volvox* (3.5x105cells.l-1). On the other hand, in station NC *Botryococcus braunii* and *Pyramimonas acuta* were the most dominant species (2.66x105cells.l-1). *Ophiocytium cochleare* (2.58x105cells.l-1) was abundant at NU while, in NH *Pyramimonas acuta* (2.16x105cells.l-1) constituted the principal species. Of the 10 species of phytoplankton observed at NZ, *Melosira granulate* (3x105cells.l-1) was the most abundant.

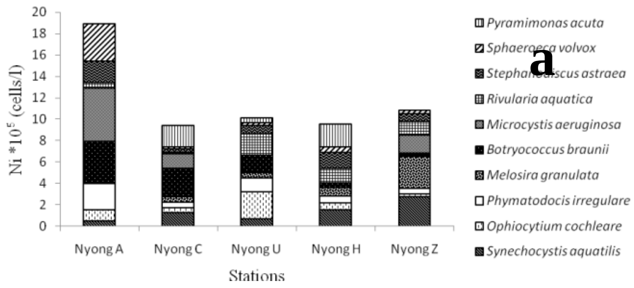

Fig. 3a: Spatial evolution of abundance of 10 phytoplankton species in Nyong low tide

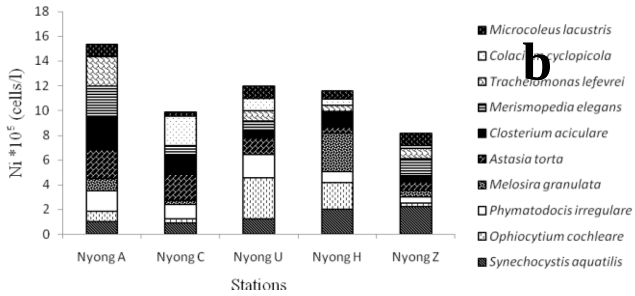

Fig. 3b: Spatial evolution of abundance of 10 phytoplankton species in Nyong high tide

According to Fig.3.b, station NZ was made up of all ten specie in variable proportion at high tide while other stations were deprived of some; e.g. in NH, *Merismopedia elegans* species was absent. In NU, nine species were common; *Ophiocytium cochleare* (3.33x105cells.l-1) was the most dominant. *Colacium cyclopicola* (2.41x105cells.l-1) and *Astasia torta* (2.08x105cells.l-1) were more abundant at NC. NC, NU and NH in brackish water of both tides. Along the river, systematic taxonomic analysis of the sampling stations shows NU, NH and NZ were more diversified at Low Tide with 74, 67 and 62 species respectively, while High tide, productive stations were NU, NZ and NC, with 65, 63 and 62 species respectively. Spatiotemporal variability in the abundance of species was observed in the order of 1% to 2% as shown in Fig. 4.

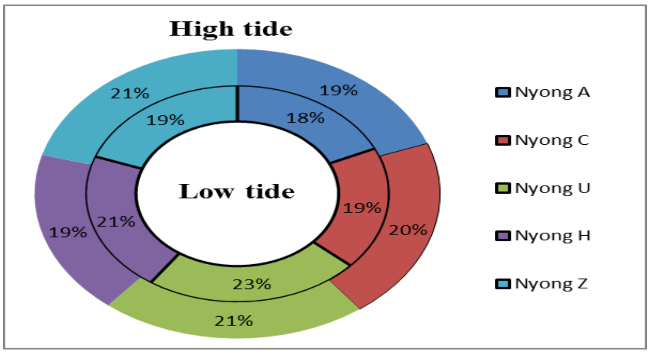

Fig 4: Taxonomic analysis of the sampling stations

III. DISCUSSION

These results are in line with [19], who documented phytoplankton species in the freshwater of some Cameroon's rivers and wetland. Chlorophyta was the most predominant in the Nyong estuary revealing the abundance and wealth (specific richness) within the phytoplanktonic population of 68 species. The occurrences of more species in brackish waters (NC, NU and NH) attest to the high productivity of estuarine ecosystem [19], In general, the spatial distribution of species in station NU was 106 species, NH (105), NC (96), NA (87), and NZ (63). These results are in line with [20], [21], who carried out research on the Gulf of Guinea estuarine system. Our result also indicates that the freshwater zone (NZ) contains the ten most abundant species at both high and low tide in variable proportions, reflecting the richness of the waters of the coastal rivers of Cameroon. The occurrence of *Microcystis aeruginosa* at low tide and its absence at high tide is explained by its dependence on salinity. In an estuary governed by salt water, the salinity supports the abundance of harmful (nocive) species [22], thereby promoting the production of toxins that will consequently cause ecological harm in the development of other phytoplankton species such as *Botryococcus braunii*, totally absent in high tide [23]. The species *Melosira granulata* that appeared at both high and low tides belongs to the class of Diatomophyceae, benthic microalgae [24]. These are the species that have been moved from a mobile or solid substrate during the turbulence created by the alternation of tides. Also the diatomic microflora is quite heterogeneous and species present in all sampling stations were both attending flood and ebb tides [25]. Species of the class of Euglenophyceae namely: *Colacium cyclopicola*, *Astasia torta* and *Tracehelomonas lefevrei* were observed in varying proportions in these stations. They were species of moist soil, freshwater and marine environment [26]. This explains the fact that the Nyong sub watershed in its lower reaches is a vast marshy area consisting of mangroves forests [3]. This study showed that in the Nyong estuary algae division consist of Chlorophyta, Cyanophyta, Chrysophyta, Euglenophyta and Pyrrophyta. This heterogeneity is significant given the dispersion of diversity index, species observed in majorities can be found in Sudanian and tropical waters [27].

IV. CONCLUSION

A detailed quantitative study of the Nyong estuary involving physical and chemical parameters should be carried out in the future so that a tangible link be drawn between frequency of occurrence of algal species at different ecological zones.

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