African Journal of Biology and Medical Research
ISSN: 2689-534X
Volume 7, Issue 4, 2024 (pp. 68-78)
www.abjournals.org

DIVERSITY OF CHLOROPHYCEAE IN SOME WETLANDS OF NKWEN IN THE CITY OF BAMENDA (NORTH-WEST REGION, CAMEROON)

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Cite this article:

Ndjouondo, G. P., Choula, F., Nwamo, R. D., Fotso (2024), Diversity of Chlorophyceae in Some Wetlands of Nkwen in the City of Bamenda (North-West Region, Cameroon). African Journal of Biology and Medical Research 7(4), 68-78. DOI: 10.52589/AJBMR-DDYMNJJ3

Manuscript History

Received: 15 Aug 2024

Accepted: 13 Oct 2024

Published: 29 Oct 2024

ABSTRACT: *Chlorophyceae are one of the classes of green algae, distinguished mainly on the basis of ultra-structural morphology and at the basis of trophic chains. Human activities lead to imbalance of aquatic ecosystems and disappearance of primary producers. The aim of the study was to determine the diversity and distribution of Chlorophyceae in some wetlands of Bamenda. Data collection and samples were taken from June 2023 to May 2024 in all the study sites. The sampling of Chlorophyceae was done using plankton net for phytoplankton, and scrabbing for periphyton. Diversity indices showed significant variations in the different study sites. The species richness amounted to 3 orders divided in 11 families, 13 genera and 22 species. The most dominant family was Chlamydomonadaceae with 5 species; followed by Selenastraceae with 4 species. Chlorophyceae are not more diversified in Nkwen Rivers. They are greatly adaptive and characterized organisms, and may survive in different environmental conditions.*

KEYWORDS: Chlorophyceae, Chlamydomonadaceae, Diversity, Wetlands, Bamenda.

Article DOI: 10.52589/AJBMR-DDYMNJJ3
DOI URL: https://doi.org/10.52589/AJBMR-DDYMNJJ3

INTRODUCTION

Chlorophyceae, the majority constituents of phytoplankton, are absorbed by zooplankton and small animals. These themselves constitute food for larger consumers who, in turn, are eaten by other predators. These algae are thus at the base of the aquatic food chain. Phytoplankton are not appreciated exclusively by zooplankton, they are a food of choice for larger filter-feeding species such as oysters and mussels, in their larval stage and throughout their adult life. Feeding on all levels of the pyramid, including the ground floor, man also consumes phytoplankton **(Dibong and Ndjouondo, 2014)**.

Cameroon has an important hydrographic network like the city of Bamenda. In Bamenda Town (North-west, Cameroon), major wetlands occur along the Mezam River floodplains and its tributaries especially in Ngomgham, Mulang, Ntenefor, Below Foncha, and Mile 4 Nkwen. The lawless occupation of wetlands has intensified recently due to demographic pressure as soils in these areas are very fertile and support year-round market gardening. Some human activities in these wetlands (land reclamation, waste disposal, deforestation, agriculture, industrialization, etc.) have led to the degradation of most of these ecosystems **(Nyambod, 2010)**.

However, wetlands are the center of interest for human activities such as food, agriculture, industry and leisure. Maintaining the quality of these waters is a major concern for available water resources **(Ndjouondo et al., 2017)**. Taking into account the alterations caused by human activities on these hydrosystems currently appears to be a major concern. This context today requires a multidisciplinary approach to anthropogenic effects combining the study of biological and physicochemical components. The objective of the study was to determine the diversity and distribution of Chlorophyceae in some Nkwen wetlands in Bamenda.

MATERIALS AND METHODS

Description of the study area

Bamenda (5°56’ - 6°00’ N and 10°08’ - 10º12’ E) is the head quarter of Mezam division in the North-West Region of Cameroon **(Fig. 1)**. It is made of three subdivisions (Bamenda I, Bamenda II, Bamenda III) with 391 km as total surface area. Its relief consists of interspersed plateaus with deep valleys. Its vegetation is the Guinea Savannah type with moderate temperatures. There are two topographic units separated by a high scarp-oriented NE-SW **(Neba, 1999)**. Above the cliff, stands the upper plateau which is mainly Bamenda I and represents 10% of the total area of the city. Altitudes here vary between 1472 m and 1573 m. The climate is the type of humid tropical highland characterized by two seasons: rainy and dry. The temperature here is very cold especially in the morning and evening with the coldest temperature between the periods of January to March with minimum temperature from 14.1-17.8 ^{o}C and maximum temperature from 22.5-28.5 oC, humidity ranging from 39%-90% and rainfall from 0.1-14.1 inches of rain per hour (Climate-Date.org>Cameroon>Northwest Bamenda). The rainy season is generally longer and lasts for 8 months (mid-March to mid-October) with a short dry season of 4 months (mid-October to mid –March) **(Tita et al., 2012)**, and mean annual temperature is 19.93 °C.

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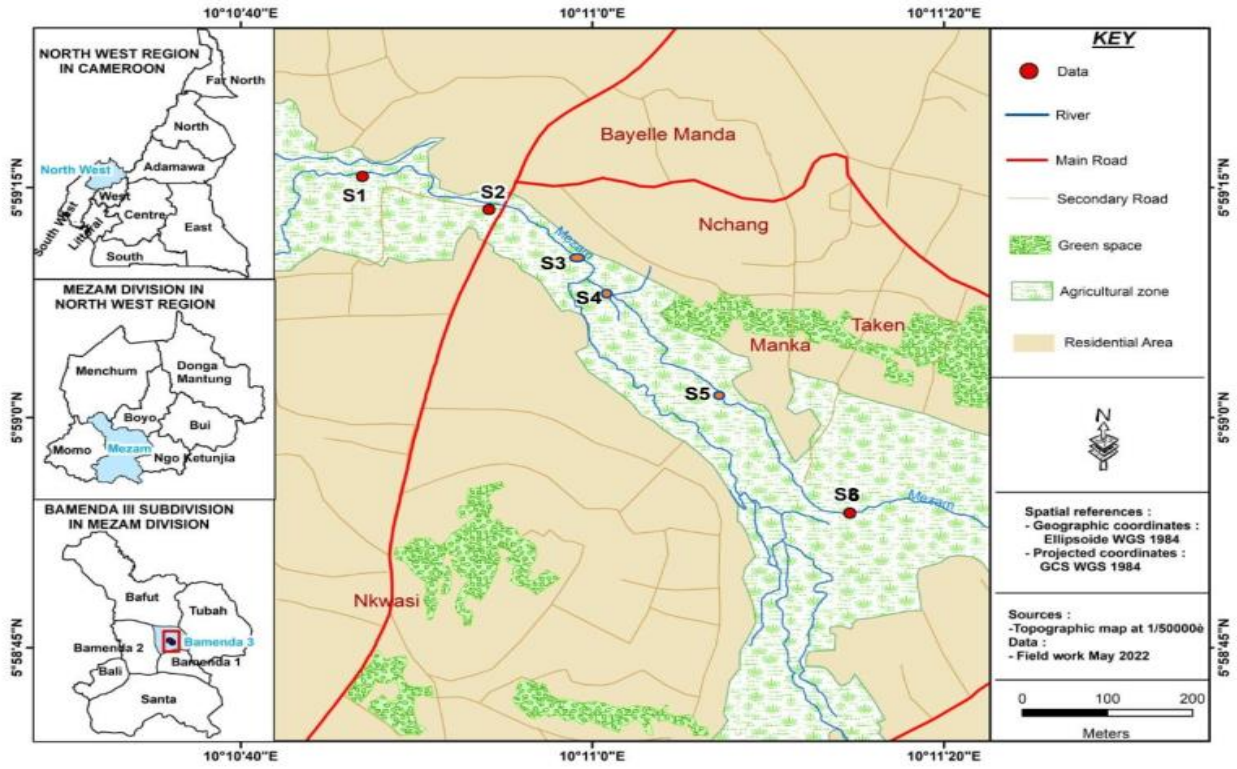

Figure 1. Localization of the study sites (Field work, 2022 modified).

Six (6) sites were delimited. Each site was found around a bridge, and near the road because accessibility and security.

Table 1. Description of study sites.

Site	Geographical coordinates	Location
1	5°57'45.80244'' N and 10°10'4.97892'' E	Mile 2, opposite "Miracle informatique"
2	5°58'33.2634'' N and 10°10'39.01548'' E	Mile 3, Farmer's house junction
3	5°59'2.38164'' N and 10°10'50.36196 E	Mile 4, respectively near FOKOU
4	5°59'22.7724'' N and 10°11'29.4468'' E	Mile 4, New road
5	5°59'58.08696'' N and 10°12'26.1918'' E	Mile 5, behind SHUMAS
6	6°00'22.06944'' N and 10°13'1.50456'' E	Mile 6, Apostolic junction

Sampling and analysis of Microalgae

Sampling of Chlorophyceae

Water from the river was filtered through the plankton net. The sample was transferred into the 150 ml bottle. A surface of 30 × 30 cm^2 was delimited on the rock sides exposed to the water and macrophytes, scraped and squeezed; residues were transferred in the 150 ml. Formalin was fixed in the sample for preservation at 5%. All the samples were transferred to the laboratory for analysis.

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Analysis of Microalgae

Qualitative analysis

In the laboratory, after dumping and homogenization of samples, some subsamples more concentrated were diluted by distilled water in the 100 ml beakers; the less concentrated samples were transferred directly in the 50 ml beakers; but the microfiltration was done on the non-concentrated samples. After 24 h sedimentation, a drop of each subsample was mounted between slide and lamella, and observed by the microscope with 3 replications. Some identification keys were used during the analysis: **Guiri and Guiri (2022)**, **Iltis (1980)**, **Bourrelly (1966, 1968)**, **Compere (1967)**.

Quantitative analysis

After homogenization of samples, 1 ml of each was taken by a micropipette and dumped in the Malassez's slide; then mounted in the light microscope where the counting was done. During the counting, 1 isolated cell, 1 colony and 1 filament of 100 µm were considered like 1 individual.

Determination of biological parameters

Species richness

This is the total number of taxa identified in a sample (P). $P = \sum_{i=1}^{n} Ni$ with Ni = identified species. Simpson's D index is $D = WNi\ (Ni-1)/N(N-1)$ or $D = Wpi^2$. This index represents the probability that two individuals selected at random from a sample belong to the same species. The Shannon-Weaver index (H') corresponds to the value calculated from the formula: $H' = -\sum((ni/N) \times \log_2 (ni/N))$ with ni = number of individuals belonging to a species, N = total number of species. The regularity of Pielou (J) is given by the formula: $J = H'/\log_2 S$, with S = total volume. To know the number of dominant species, the Hill index is calculated = (1/D)/expH'.

Density of microalgae

Density (D) of Microalgae is given using the following formula: $D = Ni \times 1000 \times v/V$, where D is the number of individuals per liter (ind./l), Ni = number of individuals for a given species, V = volume of the sample and v = volume of the subsample counted in ml.

Statistical analysis

Microsoft Office Excel software was used for keying and coding data collected during the study. Qualitative and quantitative variables were presented as frequency and mean ± standard deviations respectively in charts. Correspondence Factor Analysis (CFA) was applied to stand composition to group sampling sites according to their floristic similarities.

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RESULTS

Species richness

The species richness amounts to 3 orders divided in 11 families, 13 genera and 22 species **(Table 2)**. The most dorminant family is Chlamydomonadaceae with 5 species, followed by Selenastraceae with 4 species.

Table 2. Floristic richness of Chlorophyceae in the study sites.

Orders	Families	Genera	Species
Sphaeropleales	Selenastraceae	*Ankistrodesmus*	*Ankistrodesmus gracilis* (Reinsch) Korshikov
			Ankistrodesmus spiralis (W.B. Turner) Lemmermann
		Monoraphidium	*Monoraphidium setiforme* (Nygaard) Komhrkov-Legnerova
			Monoraphidium arcuatum (Korshikov) Hindak
	Cylindrocapsaceae	*Cylindrocapsa*	*Cylindrocapsa geminella* Wolle
	Radiopcoccaceae	*Gloeocystis*	*Gloeocystis vesiculosa* Nägeli
	Hydrodictyaceae	*Pediastrum*	*Pediastrum duplex* Meyen
	Scenedesmaceae	*Scenedesmus*	*Scenedesmus acutus* Meyen
			Scenedesmus quadricauda (Turpin) Brebisson
Chlamydomonadales	Chlamydomonadaceae	*Chlamydomonas*	*Chlamydomonas globosa* J.W. Snow
			Chlamydomonas ovata P.A. Dangeard
			Chlamydomonas reinhardti Dangeard
			Chlamydomonas ehrenbergii Ehrenberg
			Chlamydomonas elegans G.S.West
	Haematococcaceae	*Chlorogonium*	*Chlorogonium elongatum* (P.A.Dangeard) Francé
		Haematococcus	*Haematococcus lacustris* (Girod-Chantrans) Rostafinski
	Volvocaceae	*Eudorina*	*Eudorina elegans* Ehrenberg
	Goniaceae	*Gonium*	*Gonium pectoral*e O.F.Müller
	Chaetophoraceae	*Stigeoclonium*	*Stigeoclonium aestivale* (Hazen) F.S.Collins
			Stigeoclonium elongatum

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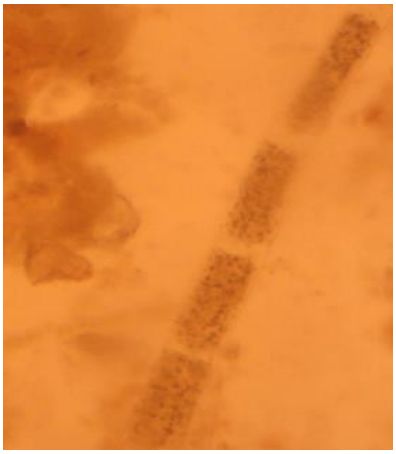
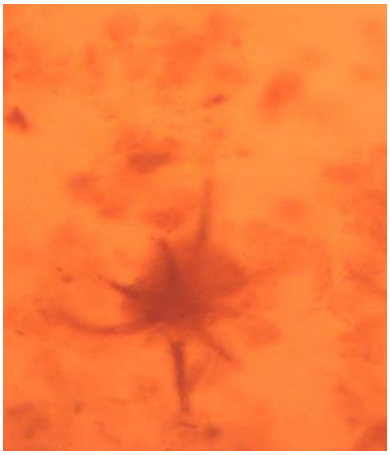
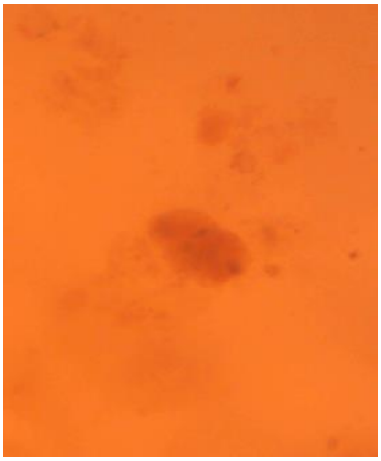
Oedogoniales	Oedogoniaceae	*Oedogonium*	*Oedogonium varians* Wittrock & Lundell ex Hirn
			Oedogonium punctato-striatum De bary



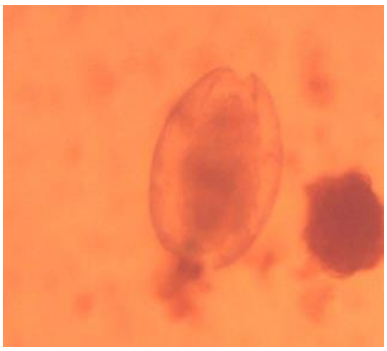
Oedogonium punctatostriatum



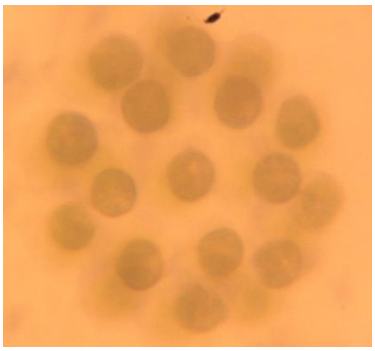
Ankistrodesmus gracilis



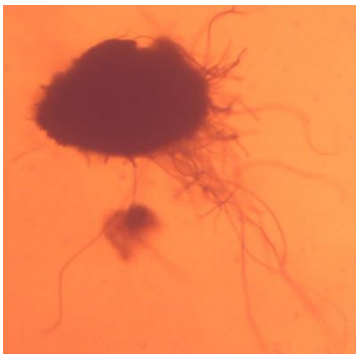
Chlamidomonas ovata



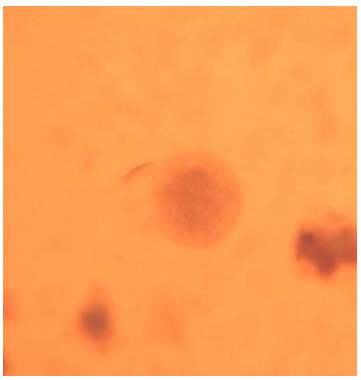
Chlamidomonas ehrenbergii



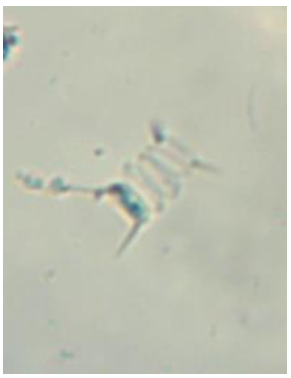
Eudorina elegans



Stigeoclonium aestivale



Haematococcus lacustris



Scenedesmus quadricauda

Figure 2. Some dominant species in the study site.

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Diversity indices

Simson's index is high in site 3 of 0.88 ± 0.45; this shows a low diversity of species **(Table 3)**. Shannon-Weaver's diversity index is low in the study sites with a minimum obtained in site 3 of 0.23 ± 0.11. Pielou's equitability follows the same direction like Shannon-Weaver's diversity index of 0.33 ± 0.01 in site 3. Hill's index is variable between the study sites with the lower value of 0.54 ± 0.14 in site 6 and the higher value of 0.76 ± 0.40 in site 5.

Table 3. Variation of diversity indices in the study sites.

Indices	Site					
	1	**2**	**3**	**4**	**5**	**6**
D	0.22 ± 0.12	0.25 ± 0.02	0.88 ± 0.45	0.34 ± 0.24	0.40 ± 0.33	0.41 ± 0.61
H'	1.88 ± 0.67	1.83 ± 1.21	0.23 ± 0.11	1.26 ± 0.89	1.12 ± 0.64	1.18 ± 0.04
J	0.81 ± 0.25	0.79 ± 0.56	0.33 ± 0.01	0.70 ± 0.55	0.80 ± 0.53	0.66 ± 0.54
e^H/S	0.65 ± 0.20	0.62 ± 0.44	0.63 ± 0.21	0.58 ± 0.20	0.76 ± 0.40	0.54 ± 0.14

D = Simson's index, H' = Shannon-Weaver's diversity index, J = Pielou equitability index, e^H/S = Hill's index.

Distribution of species in the study sites

The correspondence factorial analysis following the factorial axes F1×F2 with 89.48% inertia brings together the study sites according to their floristic similarity **(Fig. 3)**. It appears that the majority of species are characteristic of the study sites, with the exception of a few species, common to the sites. These are *Ankistrodesmus gracilis*, *Chlamidomonas ehrenbergii*, *Oedogonium varians*, *Stigeoclonium elongatum*.

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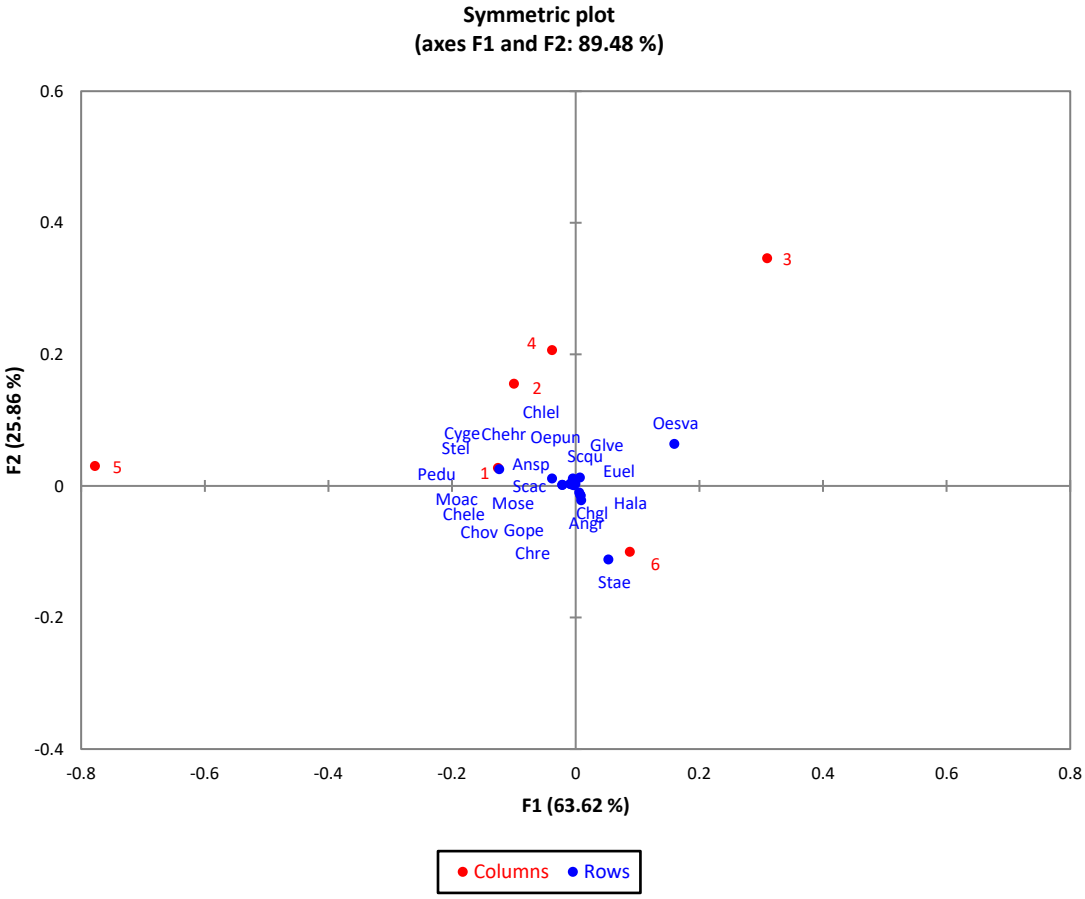

Figure 3. Distribution of species according to the study sites (*Ankistrodesmus gracilis* = Angr, *Ankistrodesmus spiralis* = Ansp, *Chlamydomonas globosa* = Chgl, *Chlamydomonas ovata* = Chov, *Chlamydomonas reinhardti* = Chre, *Chlamydomonas ehrenbergii* = Chehr, *Chlamydomonas elegans* = Chele, *Chlorogonium elongatum* = Chlel, *Cylindrocapsa geminella* = Cyge, *Eudorina elegans* = Euel, *Gloeocystis vesiculosa* = Glve, *Gonium pectorale* =Gope, *Haematococcus lacustris* = Hala, *Monoraphidium setiforme* = Mose, *Monoraphidium arcuatum* = Moac, *Oedogonium varians* = Oesva, *Oedogonium punctatostriatum* = Oepun, *Pediastrum duplex* = Pedu, *Scenedesmus acutus* = Scac, *Scenedesmus quadricauda* = Scqu, *Stigeoclonium aestivale* = Stae, *Stigeoclonium elongatum* = Stel.

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Density

Density varies in the study sites **(Fig. 4)**. The maximum total density is reached at site 6, of 5206 Ind./l. The abundant family is Oedogoniaceae with 3200 Ind./l at site 6, followed by Haematococcaceae with 1500 Ind./l at sites 1 and 3.

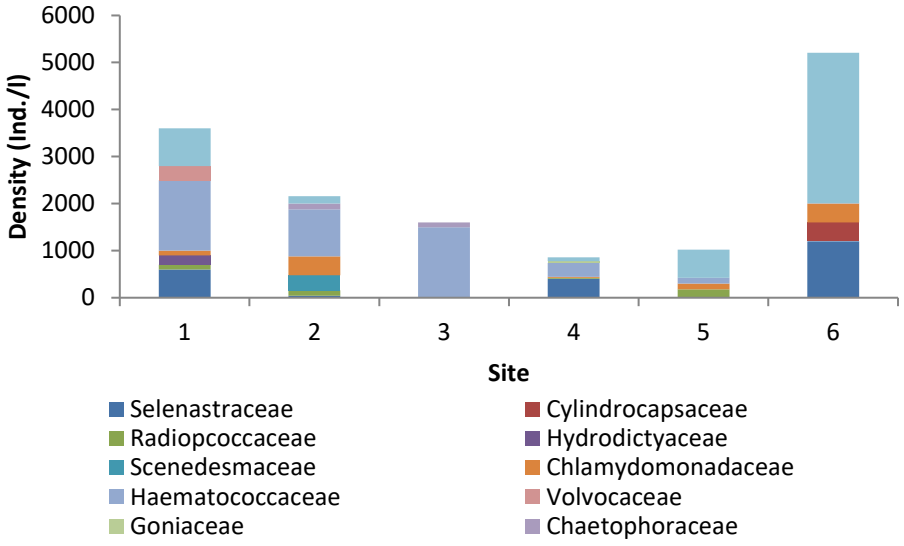

Figure 4. Variation of density of different families in the study sites.

DISCUSSION

The results of the species richness amounting to 22 species show a significant wealth in the sampling sites with the most represented family being Chlamydomonadaceae (with 5 species). This is because they can easily colonize available surfaces would justify their predominance in the composition of algae fixed on other plants (epiphytes). These results are similar to those of **Dibong and Ndjouondo (2014)** who sampled microalgae of Kambo and Longmayagui rivers at Douala (25 Chlorophyceae species). The same results were obtained by **Fokou (2015)** who focused on phytoplankton from the Tongo'o Bassa River at Douala (28 Chlorophyceae species). Our findings are not consistent with results of **Millo (2015)** who reported Chlorophyceae was the less represented class in Batika River in Douala (12 Chlorophyceae species). This could be explained by the more rapid water flow in this river from upstream to downstream compare to those abovementioned. Higher water flows are known threaten the multiplication of microalgae due to their size and their ability to detach themselves from the supports to find themselves drifting in the current. Besides, this difference between results could also be attributed to the differences related to the quality of water. The Chlamydomonadaceae family was identified as the dominant family in terms of dominance. These authors showed that this family was abundant in waters polluted with organic matter.

The Shannon-Weaver index obtained was between 0.23 and 1.88. Standard values for ranges from 1.5 - 3.5 **(Kemka, 2004)**. A low chlorophyceae diversity index in site 3 indicates that the community is young with high multiplication rate with dominance of one or a few Taxa or that the population is subject to the influence of a single Taxa that is developing. The high diversity

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index (site 1 and 2) shows that the population is not subject to the influence of a single Taxa that is developing but rather to a strong development of several different individuals. This result is less than those obtained by **Dibong and Ndjouondo (2014)** in Kambo and Longmayagui rivers (3.8-4.95) indicating a rich diversity

Densities of Chlorophyceae showed variation between sites as the Haematococcaceae family appears to be the densest class in 4 different study sites. This is because Haematococcaceae form efflorescence (algae blooms) in streams polluted with organic matter where the speed of the current is very slow. Rivers where the speed of the current is very slow polluted with organic matter undergo strong eutrophication by letting appear efflorescence by the multiplication of one or a few species. These results are in line with those of **Aurrousseau (2013)** who worked on the evaluation of the impact of watercourses on eutrophication in the coastal band in France, **Groga (2012)** who focused on the structure, the functioning, and the dynamics of phytoplankton in Lake Ta'abo in Côte d'Ivoire and **Sana'a (2006)** who addressed the structure, dynamics and physicochemical and phytoplanktonic typologies of the Bou Regreg estuary in Morocco.

CONCLUSION

The aim of the study was to determine the diversity of Chlorophyceae in some wetlands of Nkwen in Bamenda, Cameroon. A total of 3 orders divided into 11 families, 13 genera and 22 species were identified. The most dominant family was Chlymodomonadaceae with 5 species. Some species were common in the study sites: *Ankistrodesmus gracilis*, *Chlamidomonas ehrenbergii*, *Oedogonium varians*, *Stigeoclonium elongatum*. Chlorophyceae are greatly adaptive and characterized organisms and may survive in different environmental condition with changing diversity, temperature, pH , Salinity and biological parameters.

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Article DOI: 10.52589/AJBMR-DDYMNJJ3
DOI URL: https://doi.org/10.52589/AJBMR-DDYMNJJ3