Topics of limnological research in Mexico

Coordinator
Alfredo Pérez Morales

UNIVERSIDAD DE COLIMA

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This book is dedicated to
Dr. Singaraju Sri Subrahmanya Sarma,
in gratitude for all his teachings in the world of limnology.

Index

Prospective Analysis of Major Phytoplankton Groups in Some Freshwater Bodies in Campeche, Southeastern Gulf of Mexico

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Abstract

A prospective analysis of major groups of phytoplankton and its abundance in some freshwater bodies of the state of Campeche is presented. Water-bottle quantitative phytoplankton samples were taken from seven freshwater bodies (waterholes, rivers, and a lagoon) in March and June 2019 and January 2020 (dry, rainy, and northern wind seasons, respectively). Twelve physicochemical parameters (water temperature, salinity, conductivity, pH, water hardness, dissolved oxygen, oxygen saturation, nitrates, nitrites, ammonium, phosphates, and silicates) were recorded. Phytoplankton was dominated by cyanobacteria (up to 1.08×10^6 cell/l) in the windy and rainy seasons, followed by diatoms (up to 3.40×10^5 cell/l) in the rainy season; chlorophytes and euglenophytes were rare. Nanoflagellate and dinoflagellate abundances were on the order of magnitude of 10^3 to 10^5 cell/l; both groups showed maximum averages in the rainy season. In general, wider ranges in values of physicochemical characteristics were recorded in the windy season. Water temperature (24.3 to 31.9°C; $F=11.30$, $p<0.005$) and pH (6.64 to 8.80; $F=2.99$, $p<0.005$) showed seasonality, as did nitrates, ammonium, and phosphates. Phosphate concentrations at five sites exceeded the maximum permissible limit (5 mg/l) of the water quality criteria for the protection of aquatic life in the rainy season (up to 69.96 mg/l) and the windy season (up to 71.99 mg/l). They also exceeded the maximum permissible limits (0.1 mg/l) for waters for human use and consumption during the same seasons. Two sites, Ulumal (river) and Zoh Laguna (waterhole), showed strong ammonium contamination (up to 50.1 and 60.8 mg/l, respectively) in the rainy season.

Keywords

Anthropogenic, eutrophication, cyanobacteria, microalgae, waterhole.

Introduction

Freshwater phytoplankton are important because they are part of trophic webs as producers of oxygen and are indicators of environmental conditions of the water bodies in which they live (Naselli-Flores & Padisák, 2023). In this context, the study of phytoplankton communities through the analysis of fluctuations in their taxonomic composition is a key methodology for characterization of various types of freshwater ecosystems. Over time, it will facilitate obtaining metrics for the evaluation of the ecological health of aquatic habitats (Ebro Hydrographic Confederation, 2005).

In Mexico, studies of freshwater phytoplankton date back to 1843; however, some authors agree that the present knowledge of its ecology is limited (Montejano et al., 2000; Mora-Navarro et al., 2004; Novelo & Tavera, 2011). In particular, the study areas along the Yucatan Peninsula, restricted spatially, have provided little detailed information about the influence of hydrological parameters on phytoplankton composition and diversity (Sánchez-Molina & Zetina-Moguel, 1993; López-Adrián & Herrera-Silveira, 1994; López-Adrián & Barrientos-Medina, 2005, Álvarez-Góngora et al., 2012).

Phytoplankton studies in the state of Campeche have been focused on the coastal zone with an emphasis on harmful species (Poot-Delgado, 2016; Poot-Delgado et al., 2021). In the southern part of the state, studies on fluvial-lagoon water bodies predominated (Muciño-Márquez et al., 2014; Poot-Delgado et al., 2015, 2018). However, the state has favorable geohydrological conditions for the reception and storage of significant volumes of water from rainfall (Conagua, 2020). This allows the presence of temporary (waterhole) and permanent aquatic bodies, such as rivers, lakes, and lagoons (Rebolledo-Vieyra, 2010). Therefore, it is necessary to generate basic ecological information on the phytoplankton of the diverse freshwater bodies in the study area.

This pioneering study describes the abundance of predominant phytoplankton groups in response to limnological conditions during three climatic seasons (dry, rainy and windy) in some freshwater bodies in the state of Campeche.

Materials and Methods

Seven freshwater bodies, located in the municipalities of Calkiní (1), San Francisco de Campeche (1), Champotón (2) and Calakmul (3) in the state of Campeche, southeastern Mexico, were sampled on March 8 (dry season) and June 17, 2020 (rainy season), and on 16 January 2020 (Fig. 1; Table 1). Sampling sites are distinct geographic locations where data are collected, often with unique environmental characteristics.

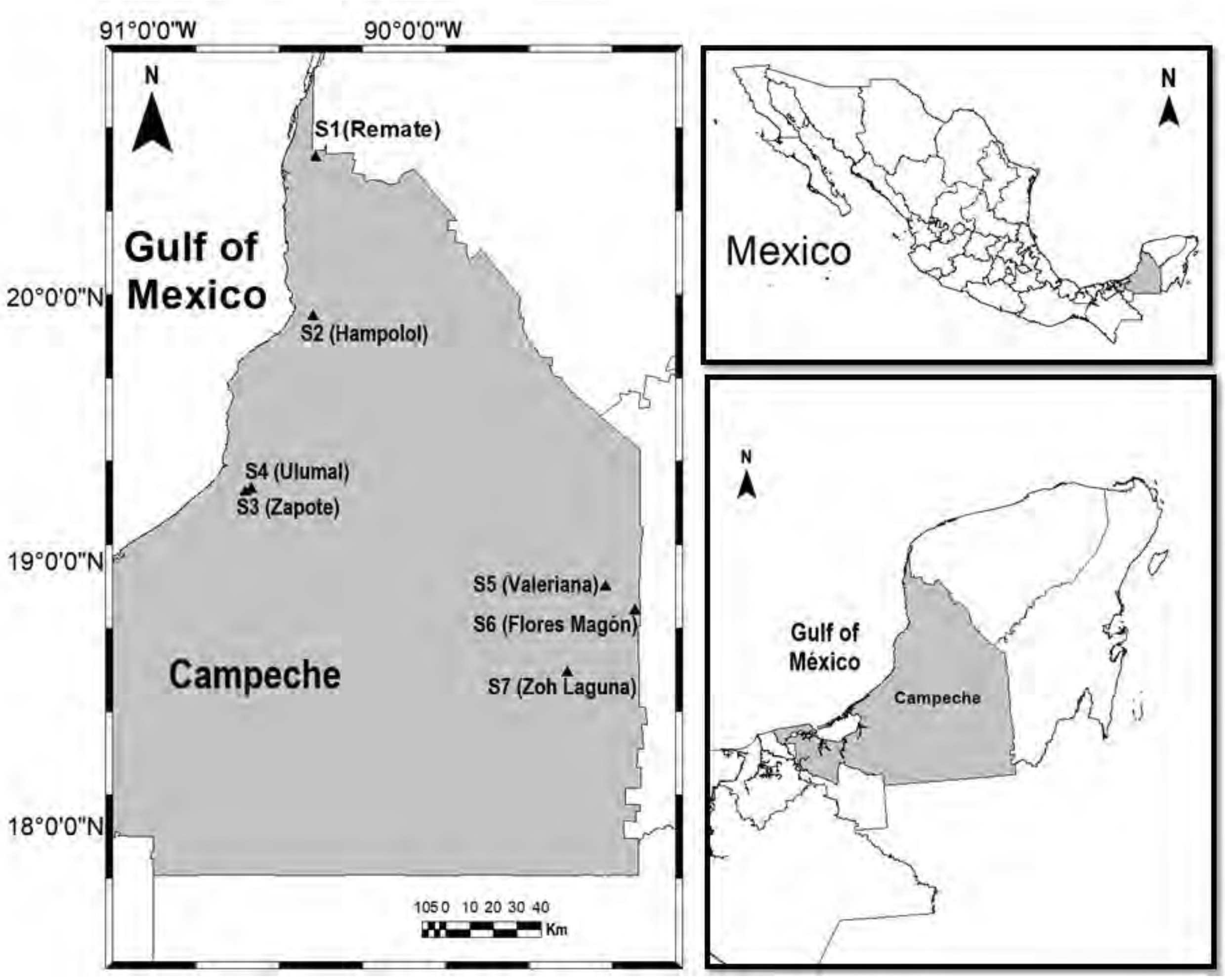


Figure 1. Study Area and Sampling Sites of Freshwater Bodies in the State of Campeche, Southeastern Gulf of Mexico.

Sampling Sites

Remate: It is a natural spring or a waterhole, also called an “ojo de agua” (in Spanish), located 47 km from Calkiní, which runs through a channel 8 km long toward the sea. Low-impact ecotourism activities, such as swimming, are practiced at the site (Arriaga-Cabrera et al., 2002).

Hampolol: There are waterholes, and it is an ejido (a communal farmland) located in the southeast of the Yucatan Peninsula, 23 km from the municipality of San Francisco de Campeche. At this site, low-impact ecotourism activities are practiced, such as swimming and tourist walks (Arriaga-Cabrera et al., 2002).

Champotón River: It is a perennial river approximately 47 km long, with a general route from East to West that drains a basin of 650 km^2. The National Commission for the Knowledge and Use of Biodiversity (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad [CONABIO]) considers the Champotón River as a priority hydrological region, presenting a modification of the environment due to fires (in the headwaters), water pollution, domestic waste, and discharge from the sugar mill (Arriaga-Cabrera et al., 2002).

Calakmul Waterholes: They are situated in the municipality of Calakmul, in the southern part of the Yucatan Peninsula (Navarro-Olmedo et al., 2018). Calakmul is characterized by calcareous soil, which causes rainwater to filter quickly, and it has no permanent water bodies. However, there are areas where the characteristics of the terrain allow the accumulation of precipitation, forming water bodies known locally as “aguadas”; these are the only sources of water for wildlife and humans of the region during the dry season. The size of the water bodies varies from ca. 100 m^2 to several hectares. However, most are small, less than 1 ha, and dry quickly at the beginning of the dry season (Reyna-Hurtado et al., 2010).

Table 1. Characteristics of the Sampling Sites in Some Freshwater Bodies in the State of Campeche, Southern Gulf of Mexico.

Municipalities	Geographic coordinates	Stations/sites	Type of water body*	Anthropogenic activity
Calkiní	20°32’3.88”N, 90°22’13.37”W	Remate (S1)	Waterhole	Tourism and Recreation
Campeche	19°56’1.10”N, 90°22’49.25”W	Hampolol (S2)	Waterhole	Tourism and Recreation
Champotón	19°17’9.44”N, 90°40’16.41”W	Zapote (S3)	River	Tourism and Recreation
	19°16’51.59”N, 90°36’49.45”W	Ulumal (S4)	River	Tourism and Recreation
Calakmul	18°54’51.59”N, 89°16’41.44”W	Valeriana (S5)	Lagoon	Irrigation
	18°49’18.27”N, 89° 9’46.57”W	Flores Magón (S6)	Waterhole	Human Consumption
	18°35’14.02”N, 89°25’3.48”W	Zoh Laguna (S7)	Waterhole	Human Consumption

*Conagua (2020).

Field Sampling and Data Collection

Samples for quantitative analysis were collected from January 2019 to January 2020 at seven stations at an approximate depth of 1 m. The sampling dates for the analyses were grouped according to the meteorological conditions previously reported for the area (Ramos-Miranda et al., 2006): the dry season (February to May), the rainy season (June to September), and the windy (the northern winds) season (October to January).

Once the sampling sites were established, physicochemical parameters of the water were recorded (water temperature, salinity, conductivity, pH, dissolved oxygen (DO) and oxygen saturation (%DO) using a Hanna multiparameter water quality meter, model HI9828 (Woonsocket, RI, USA) and a Hach multiparametric probe, model HQ40d. Water hardness ($CaCO_3$) was determined with a Hach DR890 multiparametric probe (Hach, Loveland, CO, USA). Similarly, water samples were collected for subsequent determination of inorganic nutrients (nitrates, nitrites, ammonium, phosphates, and silicates) in the laboratory. Water samples were taken using an amber glass bottle with a capacity of 2 l, poured into plastic bottles previously washed with neutral detergent (Extran), 0.1 % H_2NO_3 and deionized water and subsequently were placed in a plastic refrigerator at 4°C for transportation, pending subsequent nutrient analysis.

Phytoplankton samples were taken using a plastic bottle (capacity 1 l). Samples were fixed in the field to a 1 % final neutral iodine solution and subsequently preserved by adding a stock (37 %) neutralized formalin solution to a final concentration of 4 % (Andersen & Throndsen, 2004).

Determination of Nutrients

Laboratory analyses of macronutrients (nitrites, nitrates, ammonium, phosphates, and silicates) and water hardness were performed according to UNEP (1991).

Cell Counting

Phytoplankton cells were counted according to Brierley et al. (2007), taking 10 cm^3 of the sample, which was placed in a sedimentation chamber (Utermöhl; Hydro-Bios Kiel, Germany) with a glass lid for 24 h. An Iroscope SI-PH inverted phase-contrast microscope, series 450 (Mexico City, Mexico) equipped with the 10x/0.25 Ph1 ADL and LD 25x/0.30 Ph1 objectives was used. Due to their size, among nanoflagellates (<20 µm), phototrophic and heterotrophic species were not differentiated. The abundance values are expressed in cells per liter (cell/l). To identify phytoplankton taxa, specialized literature was consulted: Schiller (1933, 1937), Cupp (1943), Dodge (1982), Komárek and Anagnostidis (1986a, b).

Data Processing and Statistical Analyses

To determine statistically significant differences, a 95 % confidence level in physicochemical variables, including inorganic nutrients, and the phytoplankton abundance between seasons, the non-parametric one-way analysis of variance (Kruskal–Wallis test) was applied (Daniel, 1993; Boyer et al., 2000). Statistical tests were performed with the Statgraphics Centurion XV program, version 18.2.06; data were plotted using the STATISTICA 7 and MS Excel 365 programs.

Results

Physicochemical Variables

The measured environmental variables are given in Table 2. The surface water temperature reached its minimum in the windy season (24.3°C), while the maximum temperature (31.9°C) was recorded in the dry season. The seasonality of temperature was confirmed by significant differences between seasons. The concentrations of dissolved salts represented in the values of salinity, conductivity, and water hardness showed similar dynamics between seasons (see Table 2). However, no significant differences were found.

The pH values ranged from a minimum of 6.68 with a standard deviation (SD) of 0.38 during the dry season to a maximum of 8.8 in the rainy and windy seasons, with a greater SD (0.82) in the windy season. Significant differences in pH were found between seasons. Of note are the low values of oxygen saturation and DO content recorded during the dry and rainy seasons; however, no significant differences were observed between season (Table 2).

Table 2. Statistics for Meteorological/Climatic Seasons for Physicochemical Variables from Seven Sampling Sites (S1-S7), in 2021-2022 (Range and Mean ± SD); the Average Minimum and Maximum Values of the Physicochemical Variables through the Study Period are Given in Bold.

Season	t°C	Salinity	Conductivity (mV)	$CaCO_3$ (mg/l)	pH	DO (mg/l)	%DO
Dry	28.80-32.60	0.18-1.86	0.40-3.80	0.33-3.08	6.68-7.73	1.40-7.01	19.70-97.70
	30.60±1.30	0.92±0.71	2.10±1.30	1.56±0.89	7.14±0.38	4.15±1.94	57.07±27.46
Rainy	28.70-30.9	0.23-2.42	0.35-3.68	0.16-7.35	7.10-8.80	1.72-6.20	21.70-80.30
	29.40±0.70	0.96±0.85	1.48±1.30	2.31±3.38	8.01±0.67	3.86±1.75	50.92±23.41
Windy	24.30-31.90	0.08-1.83	0.18-3.59	1.56-13.18	6.64-8.80	1.61-8.84	19.40-112.80
	26.20±2.60	0.99±0.65	1.60±1.30	4.58±4.13	7.67±0.82	5.52±2.53	66.59±35.37
Differences between Seasons	F=11.30 p<0.005	F=0.02 p>0.005	F=0.43 p>0.005	F=1.78 p>0.005	F=2.99 p<0.005	F=1.16 p>0.005	F=0.47 p>0.005
				>500[1]	6.5-8.5[1]		

[1]Upper limits established for human consumption (DOF, 2022).

Inorganic Nutrients

Data on inorganic nutrients are summarized in Table 3. Nitrites showed high values during the windy season; however, there were no significant differences between climatic seasons. Nitrate concentration was the highest during the dry season. Ammonium showed the maximum value during the rainy season. In general, the ammonium concentrations were low to moderate, except for Ulumal (river) and Zoh Laguna (waterhole) that presented strong ammonium contamination (up to 50.1 mg/l and 60.8 mg/l, respectively) in the rainy season. In both cases, significant differences occurred between seasons (Table 3).

Table 3. Statistics for Seasons for Inorganic Nutrients (mg/l) from Seven Sampling (S1-S7) Sites in 2021–2022 (Range and Mean ± SD); the Average Minimum and Maximum Values of the Nutrient Concentrations through the Study Period are Given in Bold.

Season	Nitrite	Nitrates	Ammonium	Phosphates	Silicates
Dry	0.35-5.38	6.63-45.25	0.14-7.94	1.61-14.86	18.40-55.80
	2.85±1.50	28.43±16.05	2.27±2.67	4.38±5.16	32.13±12.66
Rainy	0.46-7.85	6.56-27.56	6.40-60.81	13.76-69.96	3.40-59.30
	1.79±1.82	16.05±8.11	23.64±24.92	55.08±21.14	28.35±18.46
Windy	0.84-13.50	0.44-32.76	5.21-52.01	12.31-71.99	11.70-81.30
	3.25±4.57	10.40±10.87	12.37±17.49	39.0±23.64	31.49±23.02
Differences between Seasons	F=0.39 p>0.005	F=3.9 p<0.005	F=2.52 p<0.005	F=11.32 p<0.005	F=0.08 p>0.005
	0.06[1]	10.0[1]	0.50[1]	0.1[2]	

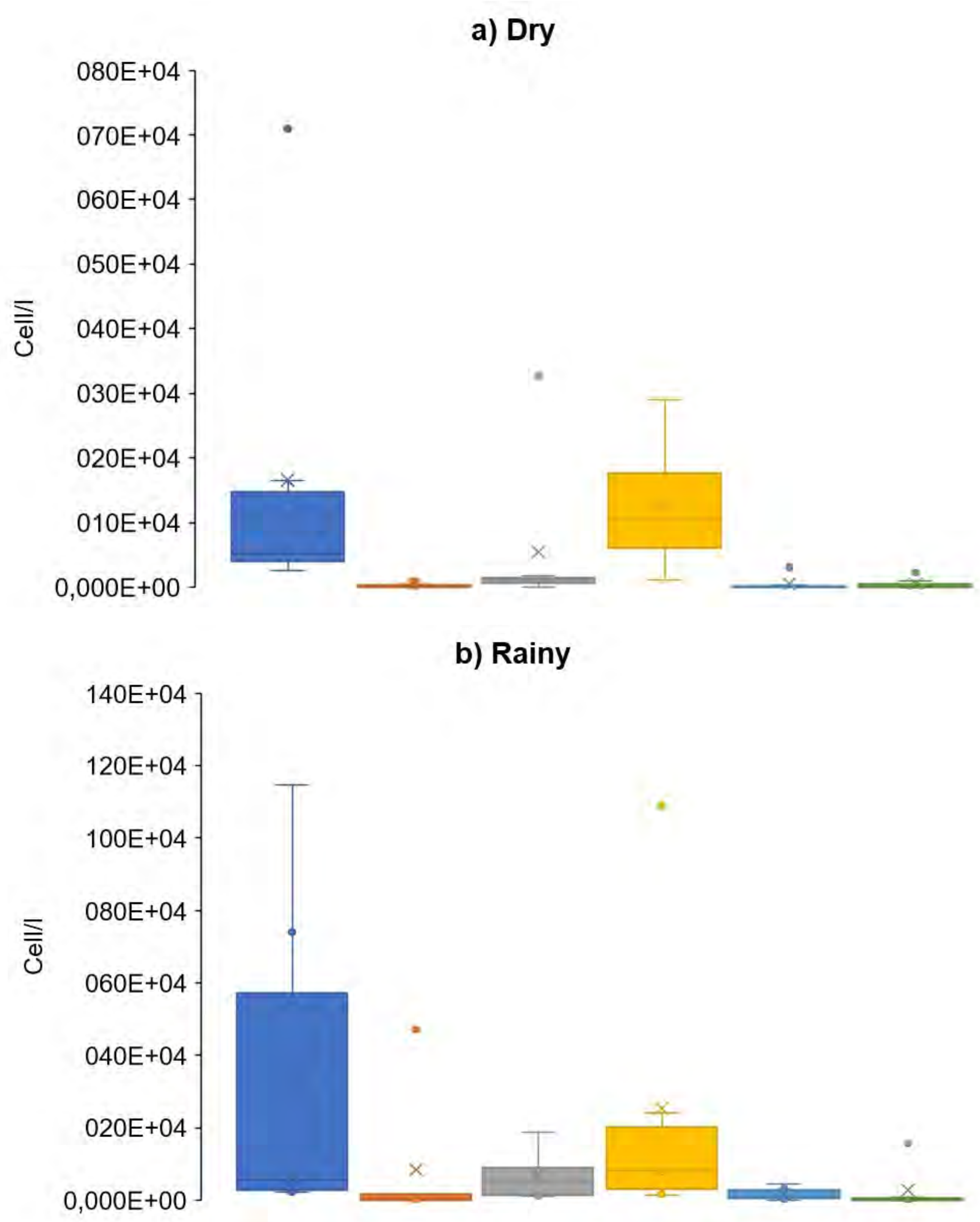
[1,2]Upper limits established for human consumption (DOF, 2019[1]; 2022[2]).

The average values of silicates during three climatic seasons were consistent across all three climatic seasons, ranging from 28.35 to 32.13 mg/l. The minimum values were recorded in the rainy season, and the highest values in the windy season. Silicate concentrations did not show significant differences between the climatic periods (F=0.08; p>0.005). The minimum phosphate values were recorded during the dry season, with the high values during the rainy and windy seasons. Significant differences were observed between seasons (F=11.32; p<0.005).

Major Phytoplankton Groups

The variation in phytoplankton abundances during the three climatic seasons for the major phytoplankton groups is given in Table 4 and Figure 2. Cyanobacteria were the dominant taxonomic group, with the same maximum value of 1.08×10^6 cell/l during the rainy and windy seasons

(Fig. 2b, c) and minimum values on the order of magnitude of 10^4 cell/l in the dry season (Fig. 2a).



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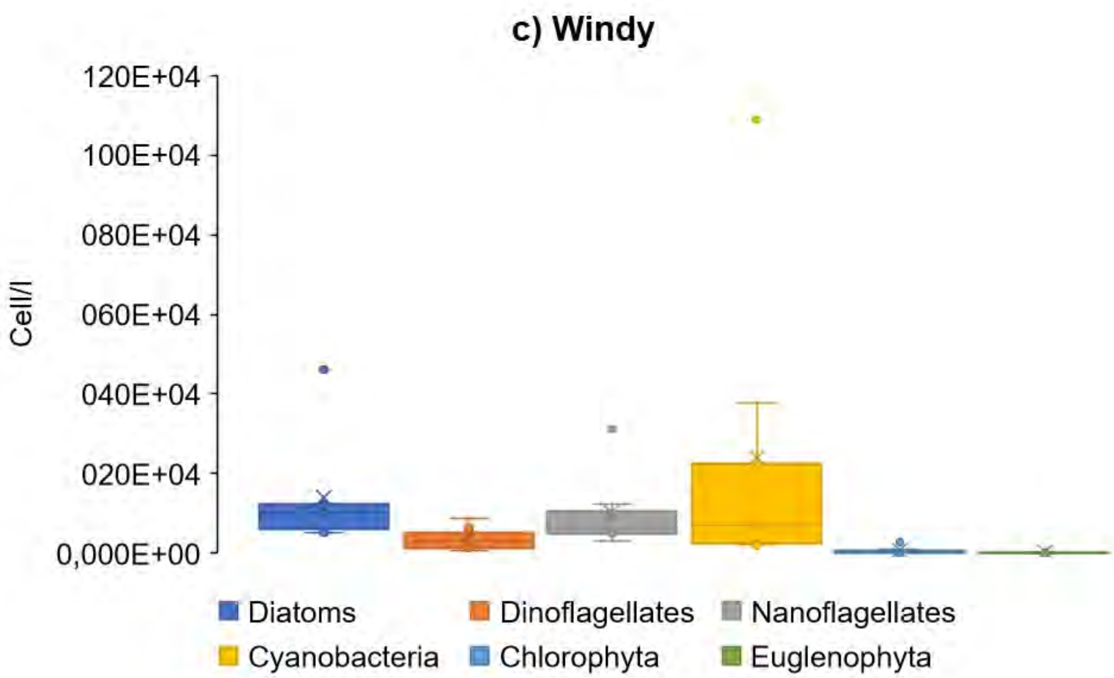

Figure 2. Abundances of Major Phytoplankton Groups in Three Seasons; a) Dry, b) Rainy and c) Windy in 2020-2021; Outliers are Indicated with a Circle.

Diatoms were the second dominant group, showing a maximum value of $1.47x10^6$ cell/l, with SD deviation of $4.84x10^5$ cell/l, during the rainy season (Fig. 2b). During the windy season, the minimum value was $5.10x10^4$ cells/l and SD $1.44x10^5$ cell/l (Fig. 2c).

Nanoflagellate and dinoflagellate abundances were on the order of 10^3 to 10^5 cell/l. Both groups showed their maximum averages during the rainy season (Fig. 2b). However, nanoflagellates showed their minimum abundance during the dry season (Fig. 2a). They were moderately abundant in the windy season at all sampling sites, except for Valeriana (in the dry season). Dinoflagellates were most abundant in the windy season with an order of magnitude of 10^4 cell/l (Fig. 2c).

Euglenophyta and Chlorophyta coincided in their minimum average values on the order of magnitude of 10^3 to 10^4 cell/l during the windy season (Fig. 2c) and their maximum average values on the order of 10^4 cell/l during the rainy season (Fig. 2b). For all major phytoplankton groups studied, no significant differences were observed between seasons (Table 4). Euglenophyta were scarce throughout all three climatic seasons studied.

Table 4. Statistics for Meteorological Seasons for Abundances of MajorPhytoplankton Groups (Cell/l) from Seven Sampling Sites (S1-S7), in 2021–2022 (Range and Mean ± SD).

Season	Nanoflagellates	Diatoms	Dinoflagellates	Cyanobacteria	Chlorophyta	Euglenophyta
Dry	6.46x103 -3.27x105	2.55x104 -7.10x105	2.15x103 -9.00x103	1.03x104 -2.90x105	3.23X103 -3.10X104	308 -2.20X104
	6.34x104 ±1.29x105	1.65x105 ±1.25x105	5.01x104 ± 3.54x104	1.25x105 ±1.01x105	1.71X104 ±1.96X104	1.04X104 ±1.09X104
Rainy	1.00x104 -1.86x105	2.20 x104 -1.47x106	3.00x103 -4.70x105	1.35x104 -1.08x106	3.00X103 -4.40X104	8.50X103 -1.57X105
	6.72x105 ±6.89x104	3.40x105 ±4.84x105	1.24x105 ±2.30x105	2.53x105 ±4.17x105	2.07X104 ±1.70X104	8.31X104 ±1.05X105
Windy	3.00x104 -3.11x105	5.10x104 -4.61x105	7.00x103 -8.80x104	2.10x104 -1.08x106	3.00X103 -2.80X104	1.00X103 -1.40X104
	1.02x105 ±9.74x104	1.40x105 ±1.44x105	3.66x104 ±2.94x104	2.39x105 ±3.94x105	1.15X104 ±1.15X104	7.50X103 ±9.19X104
Differences between Seasons	F=0.43 p>0.005	F=0.77 p>0.005	F=0.98 p>0.005	F=0.3 p>0.005	F=1.64 p>0.005	F=1.02 p>0.005

Discussion

Environmental Characterization

In general, the values of the measured physicochemical parameters showed variations related to other environmental changes, such as seasonality (dry, rainy, and windy), that had an impact on the volume of water in each water body, as well as on physical (leaching in the environment, concentration, dilution) and chemical (metamorphism, degradation of organic matter).

The values of salinity, hardness, conductivity, and pH were consistent at each point studied throughout the three climatic periods. This is because the state of Campeche is located on a platform of stratified carbonates, such as dolomites and limestones (Benítez et al., 2011). Generally, the pH of inland water bodies tends to be neutral (7), due to the high concentrations of calcium carbonates that are basic in character and is the main moderator of the carbonate-bicarbonate system (Stumm & Morgan, 1996). The values reported herein are within the maximum permissible limits for natural waters for human consumption (6.5-8.5).

In general, moderately to very oxygenated waters were observed, except for the sampling sites, Remate and Hampolol, that had slightly oxygenated waters. This could be because these sites have abundant vegetation in their surroundings which prevents the aeration of water by winds and also affects the production of oxygen through photosynthesis (Arriaga-Cabrera et al., 2002). The afore-mentioned processes are reinforced by the fact that the DO highest concentrations were measured during the rainy and windy seasons, probably due to the movement of the water masses caused by the rains and wind, resulting in their oxygenation (De la Lanza-Espino & Gómez-Aguirre, 1999).

The inter-seasonal dynamics of nitrogenous compounds was similar to that reported for natural surface waters (Gama-Flores et al., 2010), except for Ulumal (river) and Zoh Laguna (waterhole) that showed strong ammonium contamination. Nitrite concentrations at the sampling sites exceeded the maximum permissible limit for waters for human use and consumption (DOF, 2022) of 1 mg/l during at least one climatic season. It should be noted that the settlements, such as Flores Magón, Valeriana and Zoh Laguna, have water used for human consumption by the surrounding population. In Remate, Hampolol, Zapote and Ulumal, the main use of water is recreational. Nitrites in natural waters are the result of the biodegradation of nitrates and ammoniacal nitrogen among other nitrogenous compounds and are indicative of fecal contamination in natural water bodies (Pacheco-Ávila & Cabrera-Sansores, 2003).

Nitrate high concentration is an important indicator of poor water quality. Its origin in natural waters is largely from the use of fertilizers in crop fields, which causes its significant increase in the receiving water bodies (Cabrera et al., 2003). For this reason, measurement of nitrate concentration is very important for the state of Campeche, which has had a notable increase in agricultural activity in recent years (Rendón-von Osten and Hinojosa, 2017). It could affect the sources of water supply for human consumption.

Phosphate concentrations during the rainy and windy seasons exceeded the maximum permissible limits (0.1 mg/l; DOF, 2022) for waters for human use and consumption. In addition, in Remate, Hampolol, Ulumal, Zoh Laguna and Flores Magón they exceeded the maximum permissible limit (5 mg/l) according to the water quality criteria for the protection of aquatic life (DOF, 2022) during the rainy and windy seasons. High phosphate concentrations could be due to possible leaching caused by rain and the significant discharge of anthropogenic (domestic) origin in nearby sites.

In particular, these bodies of water are ecosystems vulnerable to eutrophication because they act as receptors and destination points for pollutants generated and released into the environment from human activities (Pacheco et al., 2014).

Silicate concentrations of inland waters generally show a high variability that can range from 0.1 to 4,000 mg/l. However, in this study, a limited variability was observed, with a minimum of 3.40 mg/l and a maximum value of 81.30 mg/l (Table 3). These results are largely subject to the abiotic characteristics of the environment, such as temperature, salinity, and pH (Fuentes & Massol-Deyá, 2002). The above may be because silicates, such as quartz, feldspar, mica, amphibole, pyroxene, olivine, and a great variety of clay minerals, are very abundant in the Earth's crust and come from the weathering and metamorphism of rocks (Rodríguez-Vega et al., 2015).

Biological Characterization

Cyanobacteria were the most abundant group and were present at all sampling sites and during all climatic seasons studied (Fig. 1B). The highest cell abundances were observed in the Flores Magón and Zoh Laguna. These sites are considered a source of fresh water supply for human consumption. Cyanobacteria are considered the most common phytoplankton organisms associated with the eutrophication of freshwater systems (Vasconcelos, 2006). As a possible consequence, some volatile organic compounds, such as geosmin and methyl-isoborneol, are produced depending on the species of cyanobacteria; these have a direct impact on the organoleptic characteristics of the water (Pérez et al., 2008; Pérez-Morales et al., 2016).

This diversity pattern of diatoms is similar to that reported by López-Adrián & Herrera-Silveira (1994), Schmitter-Soto et al. (2001), and Sánchez et al. (2002), although the proportions differed. However, variability in diatom abundance may be due to nitrogen eutrophication, which impacts the amount of dissolved silicon (Krause et al., 2023), as can be observed in this study.

Our records of Euglenophyta are similar to those reported by Ayala-Castañares (1963), López-Ochoterena and Madrazo-Garibay (1990), and Muciño-Márquez et al. (2014): they contributed 10 % of the phytoplankton abundance in the Pom-Atasta Lagoon System (a part of a natural protected area of Laguna de Términos) and 8 % in Palizada, both in the state of Campeche.

Conclusions

Based on quantitative water-bottle samples taken during three climatic seasons (dry, rainy, and windy) in 2019-2020 at seven freshwater bodies in the state of Campeche, changes in 12 physicochemical variables and proportions between major phytoplankton groups in terms of cell abundance were followed. In general, cyanobacteria and diatoms predominated; dinoflagellates and nanoflagellates, as well as chlorophytes and euglenophytes, were much less abundant. For all major phytoplankton groups studied, no significant differences were observed between climatic seasons. In general, wider ranges in the values of the physicochemical characteristics were recorded in the windy season (January). In addition, Ulumal (river) and Zoh Laguna (waterhole) showed strong ammonium contamination. The phosphate concentrations (related to anthropogenic eutrophication) in Remate, Hampolol, Ulumal, Zoh Laguna and Flores Magón exceeded the maximum permissible limit for both the protection of aquatic life and for human use and consumption in the rainy and windy seasons.

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Authors' Contributions

Conceptualization, JAGF, CAPD, JRvO and YBO; data curation, JAGF, CAPD, JRvO and YBO; formal analysis, JAGF, CAPD, JRvO and YBO; funding acquisition JRvO and CAPD; investigation, JAGF, CAPD, JRvO and YBO; methodology, JAGF, CAPD, JRvO and YBO; resources, JAGF, CAPD, JRvO and YBO; software, JAGF, CAPD, JRvO and YBO; visualization, CAPD; writing—original draft, JAGF, CAPD, JRvO and YBO; writing—review and editing, JAGF, CAPD, JRvO and YBO. All authors have read and agreed to the published version of the manuscript.

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This book takes a significant step in showcasing the relevance of limnology to our survival. Freshwater habitats, though they cover less than 1 % of the Earth's surface, are home to a substantial portion of the world's biodiversity—at least 10 % of all known species. Freshwater habitats and the biodiversity they support are under threat. Moreover, our survival depends on access to high-quality freshwater. This book not only highlights the beauty of limnology and the scientific methods used to study it, but it also draws attention to the major causes of biodiversity loss in freshwater ecosystems. It shows all readers what it means to deal with inland waters as a scientist interested in understanding ecosystems and protecting them.

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