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Composition, Frequency of Phytoplankton Occurrence and its Correlation with Environmental Variables in the Curiaú River (Eastern Amazon)

Composição, Frequência de Ocorrência do Fitoplâncton e sua Correlação com Variáveis Ambientais no Rio Curiaú (Amazônia Oriental)

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Abstract

Phytoplankton is composed of microalgae and cyanobacteria that inhabit aquatic ecosystems as part of the plankton. These organisms play an essential role in assessing water quality, acting as important environmental bioindicators. Here, we investigated the composition and occurrence frequency of phytoplankton in the Curiaú River, located in Macapá, State of Amapá, Eastern Amazon. Additionally, we aimed to establish the relationship between species richness and key physicochemical parameters of water quality. Phytoplankton samples were collected quarterly over a year (2016/2017) using a 20 µm mesh net and preserved in Transeau solution for subsequent analysis under optical microscopy. In addition, *in situ* measurements of parameters such as pH, dissolved oxygen (DO), electrical conductivity (EC), temperature, and water transparency were made. The results showed a total of 64 taxa, grouped into 7 classes and 6 taxonomic divisions. Zygnematophyceae class was predominant, representing 69.9% of the cataloged organisms. There were significant variations in environmental parameters throughout the seasons (DO, pH, and EC) and between sampling sites (transparency and pH). Spearman correlation analysis showed a negative correspondence between water transparency with pH and EC, while there was a positive correlation between water transparency and DO. Electrical conductivity was the sole environmental variable showing a statistically significant negative correlation with phytoplankton richness. These results contribute to the advancement of phycological studies in the Amazon region and provide an important assessment of the environmental quality of the Curiaú River, a tributary of the Amazon River.

Keywords: Microalgae. Water Quality. Zygnematophyceae.

Resumo

O fitoplâncton é composto por microalgas e cianobactérias que habitam ecossistemas aquáticos como parte do plâncton. Esses organismos desempenham um papel essencial na avaliação da qualidade da água, atuando como importantes bioindicadores ambientais. Neste estudo, investigamos a composição e a frequência de ocorrência do fitoplâncton no rio Curiaú, localizado em Macapá, no estado do Amapá, Amazônia Oriental. Além disso, o estudo teve como objetivo estabelecer a relação entre a riqueza de espécies e variáveis físico-químicas da qualidade da água. As amostras de fitoplâncton foram coletadas trimestralmente ao longo de um ano (2016/2017) usando uma rede de malha de 20 µm e preservadas em solução de *Transeau* para análise subsequente em microscopia óptica. Além disso, medições *in situ* de parâmetros como pH, oxigênio dissolvido (OD), condutividade elétrica (CE), temperatura e transparência da água foram realizadas. Os resultados mostraram um total de 64 táxons, agrupados em 7 classes e 6 divisões taxonômicas. A classe Zygnematophyceae foi predominante, representando 69,9% dos organismos catalogados. Houve variações significativas nos parâmetros ambientais ao longo das estações (OD, pH e CE) e entre os locais de amostragem (transparência e pH). A análise de correlação de Spearman mostrou uma correspondência negativa entre a transparência da água com o pH e a CE, enquanto houve uma correlação positiva entre a transparência da água e o OD. A condutividade elétrica foi a única variável ambiental significativamente correlacionada com a riqueza do fitoplâncton, mostrando uma associação negativa. Esses resultados contribuem para o avanço dos estudos ficológicos na região amazônica e fornecem uma importante avaliação da qualidade ambiental do rio Curiaú, um afluente do rio Amazonas

Palavras-chave: Microalgas. Qualidade da Água. Zygnematophyceae.

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1 Introduction

Aquatic ecosystems consist of living (biotic) elements, such as plants, fish, bacteria, and microalgae, and non-living (abiotic) components, including light, sediments, and water, all of which interact dynamically (Esteves, 1998). These ecosystems are self-sustaining and provide essential ecosystem services-provisioning, supporting, regulating, and cultural services-that sustain biodiversity and human well-being (Ferreira et al., 2023; Pereira et al., 2017; Rares; Brandimarte, 2014).

Phytoplankton constitutes one of the numerous biological communities found in these ecosystems. Comprising photosynthetic microorganisms of various shapes and functions, it plays an essential role as a producer in the aquatic food chain (Huang *et al.,* 2022; Li *et al.,* 2022; Gao *et al.*, 2024). It provides initial organic matter and energy that sustains other organisms (Zhang *et al*., 2020). Remarkably, most of the oxygen available in the atmosphere is generated by the phytoplankton community in rivers, lakes, ponds, estuaries, and seas, highlighting the importance of these microorganisms for maintaining all forms of life (Carneiro *et al*., 2024. Li et al., 2022)

In addition to biotic elements, aquatic ecosystems are characterized by physical, chemical, and physicochemical parameters that serve as indicators of water quality, for example turbidity, temperature, electrical conductivity, pH, dissolved oxygen, among others (Brasil, 2014; Zhang *et al.*, 2020). Brazilian legislation addresses these issues and establishes quality standards for water bodies. Laws such as No. 9.433/1997, which deals with the National Water Resources Policy (Brasil, 1997), CONAMA resolutions 357/2005 and 397/2008 (Brasil, 2005, 2008), which classify and regulate the use of water bodies, play an important role in the protection, maintenance, and conservation of water resources in Brazil (Lopes *et al*., 2020; Lee *et al*., 2023).

The different human activities carried out on aquatic ecosystems have caused alterations in biological communities and their natural environmental characteristics (Schiller *et al*., 2017; Huang *et al*., 2022). This promotes the reduction of biological diversity and the decrease of available resources. This substantially implies their multiple uses, with a direct impact on human development and the maintenance of aquatic ecosystems (Ferreira *et al*., 2023).

The Curiaú River is an important river in the State of Amapá, Brazil, located in the Eastern Amazon. Its basin is formed by numerous temporary and permanent lakes that are influenced by the region's rainfall and tidal patterns (Queiroz, 2007). It receives sediment loads from both the Atlantic Ocean and the Amazon River (Barros *et al*., 2022), creating ideal conditions for the establishment of different biological communities. Additionally, the river is used for various purposes, including swimming, subsistence fishing, river transportation, and water supply for populations.

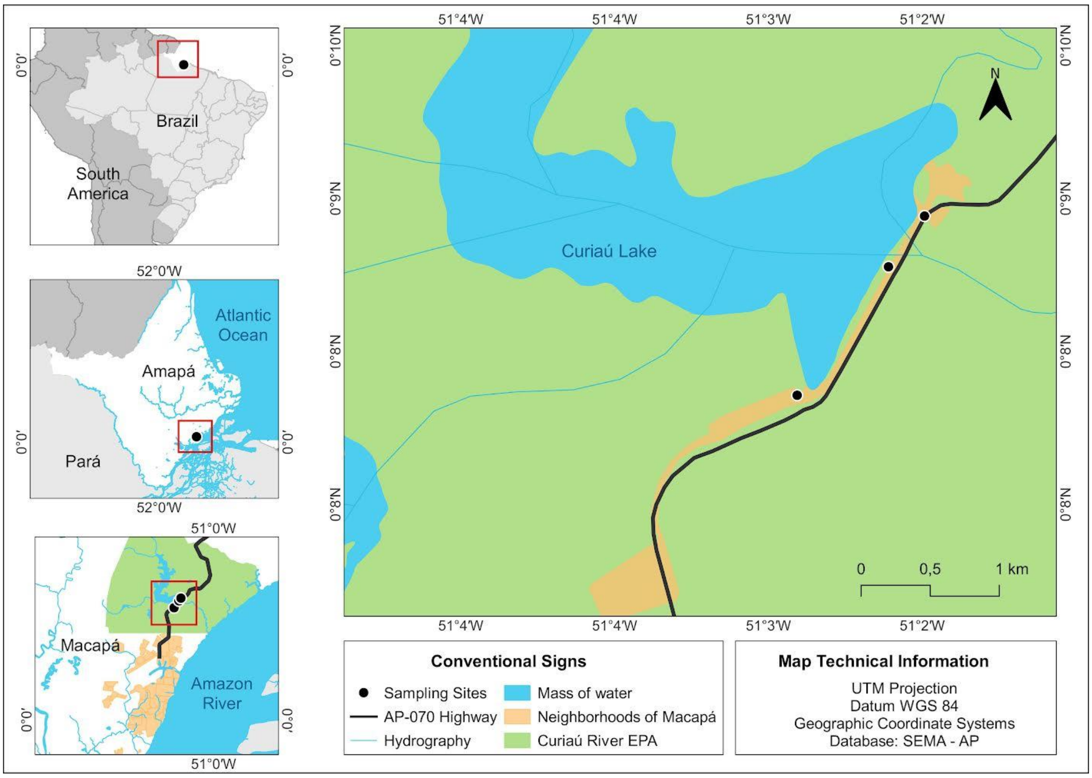
Given this, this research aims to verify the composition, frequency of occurrence of phytoplankton, and its correlation with environmental variables in the Curiaú River, located in Macapá, State of Amapá, Eastern Amazon, to identify the patterns established between this community and the parameters associated with water quality this important tributary of the Amazon River.

2 Material and Methods

2.1 Study area

Study area is located on Environmental Protection Area (APA) of the Curiaú River (Figure 1) and is situated 8 km from Macapá, the capital of the state of Amapá, in the Eastern Amazon. The Curiaú River is an important tributary of the Amazon River. The APA of the Curiaú River is a statelevel Conservation Unit (UC) designated for sustainable use. Established on September 28, 1992, by State Decree No. 1417/1992, it spans an area of 23,000 hectares. Access to the APA is facilitated through State Highway AP-070 and the Curiaú River (Barros *et al.*, 2021; Brito *et al.*, 2022).

Figure 1 - Characterization of the study area and sampling sites



Source: research data.

Located within the Curiaú River basin, the APA is characterized by numerous temporary and permanent lakes, influenced by rainfall and tidal patterns (Queiroz, 2007). The prevailing climate is hot and humid, with rainy seasons occurring from January to June and dry seasons from July to December. Annual precipitation averages 2500 mm, and temperatures range from 27 ºC to 32 ºC (Borja *et al.*, 2015; Vasconcelos; Oliveira 2011). The Curiaú River basin receives sediments from both the Atlantic Ocean and the Amazon River, boasting diverse ecological systems such as flooded fields, floodplain forests, and savanna grasslands (Queiroz, 2007) (2007).

2.2 Sampling and collection of phytoplankton

The phytoplankton samples were collected quarterly from 2016 to 2017 in the Curiaú River, covering flood, dry, and transitional seasons. The collection sites were distributed across three distinct locations, identified as sites A (Latitude: 0°08'13.69"N; Longitude: 51°02'53.35"W), B (Latitude: 0°08'43.91"N; Longitude: 51°02'31.98"W), and C (Latitude: 0°08'55.86"N; Longitude: 51°02'23.55"W).

Phytoplanktonic material was collected using a trawl net with a porosity of 20 µm. The collected material was fixed with Transeau solution, following the standard methodology described by Bicudo and Menezes (2006). By the end of the study, a total of six collection campaigns were carried out, resulting in 18 sampling units.

2.3 Taxonomic identification of phytoplankton

Taxonomic identification was conducted at the Environmental Sanitation Laboratory of the Federal University of Amapá, utilizing a conventional optical microscope as the primary analytical instrument. To perform taxonomic identification, we consulted specialized literature and taxonomic identification keys (Anagnostidis; Komárek, 1990; Bicudo; Menezes, 2006; Faustino, 2006; Silveira Júnior, 2012; Cunha *et al.*, 2013; Komárek *et al.*, 2014), as well as the Algabase digital platform.

2.4 Frequency of occurrence

The occurrence frequency (%) of taxa was determined following Matteucci and Colma (1982) For this, the number of samples in which the taxon occurred was considered alongside the total number of samples analyzed. In this study, the result was obtained using the formula: (n*100)/18, where n = number of samples in which the taxon occurred and 18 = total number of samples (spatial-seasonal) analyzed during the study period. Ultimately, taxa were classified as follows: quite common (≥70%), relatively common (<70% and ≥40%), relatively uncommon (<40% and ≥10%), and sporadic (<10%).

2.5 Monitoring physical and chemical water quality parameters

The monitor of the physicochemical parameters of water was conducted according to standard procedures, employing specific sensors, except for water transparency. Temperature and pH were measured with a pH meter (Orion Star A221), while electrical conductivity was determined using a conductivity meter (multi-scale - HI8733). Water transparency was assessed with a Secchi disk, and the dissolved oxygen content was measured using an oximeter (Hanna - HI98193/10).

2.5 Statistical analyses

The data were organized in an Excel® spreadsheet and subjected to descriptive analysis using R statistical software (R Core Team 2016). This analysis aims to assess the means, medians, standard deviations, and confidence levels (95%) of the measured values.

Additionally, the Shapiro-Wilk normality test was performed, and the homogeneity between the environmental parameter data and phytoplankton richness was evaluated. When the data were considered heterogeneous, the non-parametric Kruskal-Wallis test was used to assess the spatio-seasonal fluctuation of the evaluated variables. Tests were considered significant at $p < 0.05$.

Spearman correlation analysis was used to determine the degree of correlation between environmental variables and phytoplankton richness ($p < 0.05$). Additionally, linear regression analyses were conducted to determine the influence and explainability of pH, electrical conductivity, temperature, dissolved oxygen, and transparency variables on species richness.

3 Results and Discussion

The temperature data (°C) remained relatively stable throughout the study, ranging from 25.0 to 29.4 °C, with a mean of 27.6 ± 1.40 °C (Table 1). The lowest temperature (25.0 °C) was recorded at Site C during the rainy-dry transition season, while the highest temperature (29.4 °C) occurred at Site A during the dry season. Despite these minor fluctuations, no significant temperature variations were observed across seasonal periods (p>0,05) or between sampling locations (p>0,05).

Table 1 - *In-situ* measured absolute values of water quality parameters

Sampling Period	Sampling Sites	pH	DO (mg/L)	EC (µS/cm)	Transparency (m)	T (°C)
R-D	**A**	5.45	1.44	40.0	1.08	28.5
	B	4.98	2.44	40.0	2.4	28.5
	C	5.06	1.90	20.0	1.47	25
D	**A**	6.23	2.39	40.0	0.6	29.4
	B	5.33	0.34	20.0	1.72	27.9
	C	5.24	0.86	20.0	1.72	28.3
D-R	**A**	7.30	3.80	50.0	NA	27.3
	B	6.33	0.97	30.0	0.73	29
	C	5.38	0.68	20.0	0.55	28.5
R	**A**	5.70	3.00	20.0	1.7	28
	B	5.76	5.54	10.0	3.1	28
	C	5.67	4.20	10.0	2	28
R-D	**A**	5.73	0.40	20.0	0.8	27.7
	B	4.91	2.11	10.0	3	26
	C	4.90	2.90	10.0	1.8	28
D	**A**	6.34	NA	40.0	0.3	28.8
	B	5,55	NA	50.0	1.6	25
	C	5,52	NA	50.0	6	25
	Average	5,63	2,20	28.0	1.80	27.61
	SD (±)	0,61	1,51	15.0	1.35	1.40

NA: Not Assessed; D (dry); D-R (dry-rainy); R (rainy); R-D (rainy-dry); SD (Standard Deviation).
Source: research data.

The average water temperatures in the Curiaú River resemble those typically found in other tropical regions of Brazil, ranging from 25 ºC to 30 ºC (Abreu; Cunha, 2016). This parameter is intricately linked with other environmental factors such as dissolved oxygen saturation, color and odor of the water, and particularly in the catalyzing chemical and biogeochemical reactions prompted by temperature fluctuations (Abreu; Cunha, 2015; Damasceno *et al.*, 2015). Furthermore, when combined with factors such as depth, wind, and radiation, temperature significantly impacts the structure of phytoplankton communities (Souza; Fernandes, 2009; Zhang *et al.*, 2024), which can be crucial for seasonal fluctuations in phytoplankton (Gao *et al.*, 2024; Rodrigues *et al.*, 2007). Although this is not observed in the study area.

The average water transparency was 1.48 ± 0.84 m (Table 1). The lowest transparency was recorded at 0.30 m (site A) during the dry season, while the highest depth was 2.40 m (site B) during the rainy season. There was no significant variation between seasonal periods ($p>0,05$), but there was variation between sampling sites ($p<0.05$), with the highest values observed at site B.

Transparency levels in Brazilian rivers generally remain low, ranging from 0.2m to 2m in lentic environments (Pereira et al., 2011), as observed in Curiaú river. Values exceeding 2m are rare. While this study did not include an evaluation of river bathymetry, indicating water body depth (Zani *et al.*, 2008), it was observed that site B stands out due to channel widening and increased depth, potentially contributing to greater transparency at that location. However, the prevailing low transparency may be linked to terrigenous influences on rivers, lakes, and lagoons, particularly during the dry season (Grego *et al.,* 2009).

The dissolved oxygen (DO) levels ranged from 0.34 mg/L during the dry season (site B) to 5.54 mg/L during the rainy season (site B), with a mean of 2.20 ± 1.51 mg/L (Table 1). There was a significant variation across sampling seasons ($p<0.05$), with an increase in values during the rainy season. This trend was not observed in spatial variations ($p>0,05$).

The average levels of dissolved oxygen (DO) fell below the standards set by Resolution 357/2005 (> 5.0 mg/L) (Brasil, 2005), a finding noted for the same environment in an earlier study (Takiyama *et al.,* 2004). DO concentration is influenced by processes such as physical reaeration, photosynthesis, and organic matter stabilization (Abreu; Cunha, 2015). Low DO levels may also be associated with higher Biochemical Oxygen Demand (BOD) during aerobic bacterial decomposition, acting as a limiting factor for aquatic life and constraining the diversity of phytoplankton organisms in these ecosystems (Abreu; Cunha, 2016)

Furthermore, it was observed that higher dissolved oxygen concentrations, although still below reference values, correlated with increased water transparency in the study area. This is attributed to the enlarged photic zone, with greater sunlight incidence and enhanced primary productivity (photosynthetic rates). The primary source of dissolved oxygen in water is photosynthesis activity, directly dependent on light penetration into the water (Fiorucci; Benedetti-Filho, 2005; Gao *et al.*, 2024). Additionally, higher DO values were associated with the rainy season, when transparency tends to be higher due to thermal stratification in the water column, a characteristic of this seasonal period (Rousseaux; Gregg, 2013).

During the study, the average pH levels were 5.63 ± 0.61 (Table 1). The lowest value, 4.9, was recorded at site C during the rainy-dry transition, while the highest value, 7.3, was found at site A during the dry-rainy transition. There was significant variation in pH values between sampling sites ($p<0.05$) and between seasonal periods ($p<0.05$).

Water pH is significantly influenced by the photosynthesis and respiration processes of phytoplankton organisms, impacting its acidity or alkalinity (Sousa *et al*., 2009; Bai *et al*., 2023). It can also be affected by rock dissolution and human activities (Piratoba et al., 2017). The values of this variable fluctuate with seasons, heavily influenced by increased rainfall, resulting in the solubilization of hydrogen ions and increased water flow, neutralizing pH (Silva *et al*., 2008). In this study, lower pH values were associated with the transition period between the rainy season and the dry season, when precipitation rates start to decrease but they still influence the pH by the rise in organic acids typical of water bodies during rainier periods. This leads to increased acidity in aquatic ecosystems (Pontes; Marques; Marques, 2012).

CONAMA Resolution 357/2005 (Brasil, 2005) stipulates that pH values in water bodies should range between 6 and 9. Aquatic ecosystems with values below this range are considered acidic. The decrease in pH may be linked to increased organic matter, affecting the levels of available oxygen in the water (Silva *et al*., 2008). However, it's important to note that Amazonian rivers are naturally acidic due to continuous organic matter decomposition and the weathering process of the rocks constituting them.

pH fluctuations may also be associated with vegetation proliferation in aquatic environments. During photosynthesis, carbon dioxide consumption increases, leading to elevated pH levels (Zerveas *et al*., 2021). However, the decrease in the photic zone, caused by thermal destratification and water temperature reduction, promotes oxygen dissolution and reduces metabolic activity in these ecosystems. This results in a lower carbon dioxide release, reducing acidification (pH increase) (Mallasen *et al*., 2012). This explains the observed correlation between reduced transparency and higher pH levels.

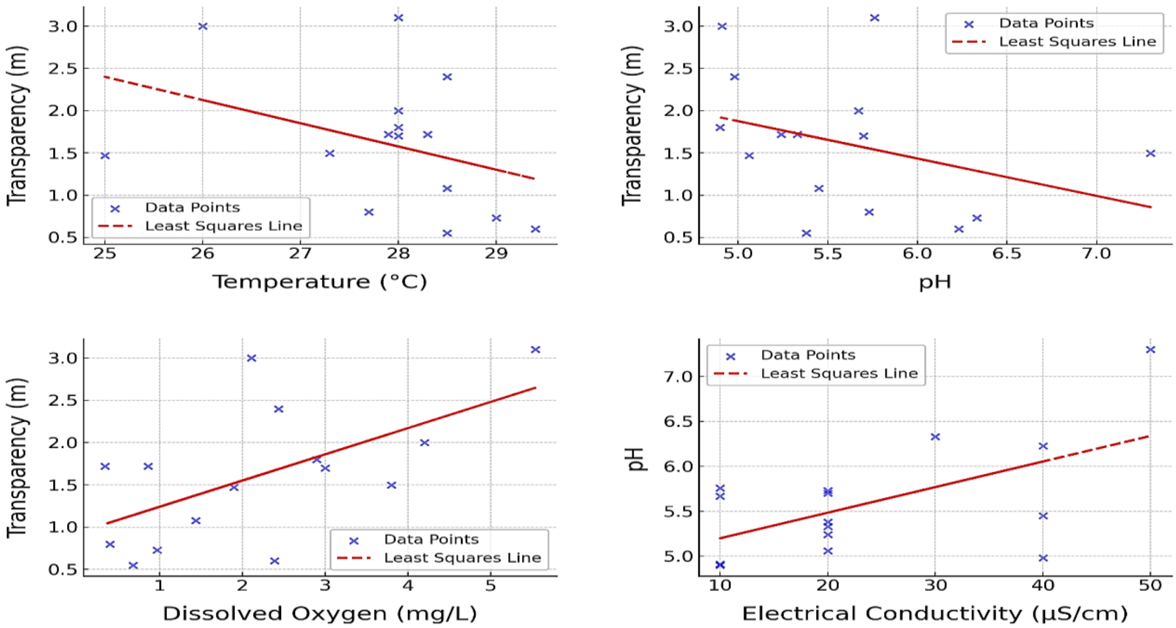
Electrical conductivity (EC) presented average values of 28.0 ± 15.0 µS/cm (Table 1). There were significant differences in values of this parameter between sampling periods ($p<0.05$), with the highest values associated with the dry season (50.0 µS/cm) (Table 1). However, no significant variations were observed between sampling sites ($p>0,05$).

The Spearman correlation test revealed a negative correlation between transparency/pH ($r^2=-0.43$; $p<0.05$) and transparency/water temperature ($r^2=-0.36$; $p<0.05$). On the other hand, EC and pH variables were positively correlated ($r^2=0.42$; $p<0.05$), as well as DO and water transparency variables ($r^2=0.52$; $p<0.05$) (Figure 2).

Seasonality impacted electrical conductivity, with lower values occurring during the rainy season. As observed by Piratoba *et al.* (2017), periods of increased precipitation tend to yield lower conductivity values due to increased water volume and subsequent ion dilution associated with this variable. Therefore, the lower conductivity values during sampling at the end of the dry season and the beginning of the rains in the region (Souza; Cunha, 2013) are linked to this condition.

Higher conductivity values were also correlated with reduced transparency values ($p<0.05$). Elevated conductivity levels may be associated with decomposition and the presence of soluble organic matter in water (Esteves, 1998; Hambly *et al.*, 2010). Increased dissolved and suspended solids result in a reduction in the photic zone, leading to reduced transparency and higher conductivity values. Additionally, electrical conductivity may be related to variables such as rainfall volume and the geochemical characteristics of rocks in the ecosystem's drainage basin, which seems more prominent in tropical regions (Silva et al., 2008).

Figure 2 - Spearman correlation between environmental parameters: a) transparency (m) and temperature (°C); b) transparency (m) and pH; c) transparency and dissolved oxygen (mg/L); d) pH and Electrical conductivity (µS/cm)



Source: research data.

Regarding the composition of phytoplankton, a total of 64 taxa were identified at the end of the study. These were classified into 7 classes and 6 taxonomic divisions (Table 2). The most representative class was Zygnematophyceae (n=46), comprising 69.9% of the taxa, followed by

Euglenophyceae (n=4) with 6.06%, Bacillariophyceae (n=4) with 6.6%, Cyanophyceae (n=3) with 4.5%, Chlorophyceae (n=3) with 4.5%, Coscinodiscophyceae (n=2) with 3.03%, Klebsormidiophyceae (n=1) with 1.5%, and Synurophyceae (n=1) with 1.5% (Figure 3). In terms of taxonomic divisions, the Charophytas group was the most expressive, totaling 47 taxa and representing 71.21% of the total cataloged organisms (Figure 4).

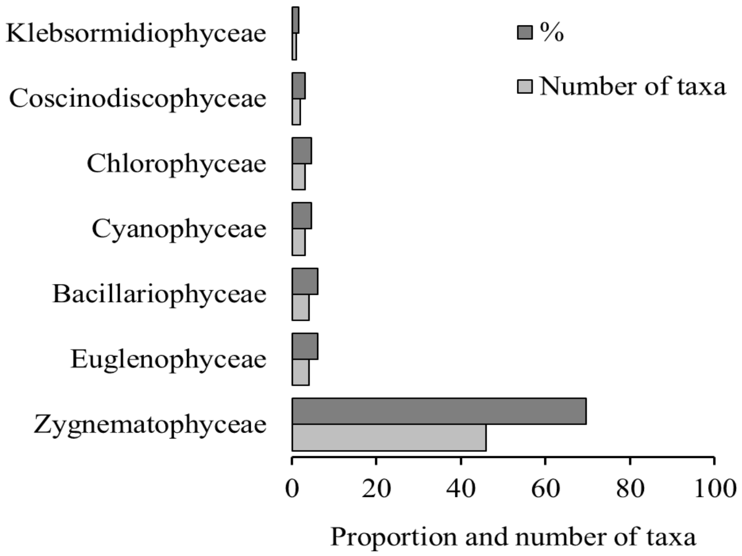
Table 2 - Identified taxa, occurrence frequency, and sampling site

Taxa	**Sampling sites**																	
	R-D			D			D-R			R			R-D			D		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Cyanophyceae																		
Aphanocapsa delicatissima	x																	
Dolichospermum circinalis	x																	
Snowella sp.				x														
Chlorophyceae																		
Kirchneriella sp.				x														
Schoroederia sp						x												
Volvox sp	x			x														
Euglenophyceae																		
Phacus gigas													x					
Phacus longicauda				x					x									
Euglena acus																		x
Euglena viridis																		x
Klebsormidiophyceae																		
Klebsormidium flaccidum					x		x											
Bacillariophyceae																		
Eunotia sp.																		x
Pinnularia sp					x													
Pinnularia viridis																x		
Placoneis sp.																x		
Coscinodiscophyceae																		
Aulacoseira sp.															x			
Aulacoseira granullata														x			x	
Synurophyceae																		
Synura uvella															x			
Zygnematophyceae																		
Bambusina brebissonii			x								x			x	x			
Closterium leibleinii				x														
Closterium lunula												x						
Closterium moniliferum													x					
Closterium parvulum															x			
Closterium setaceum					x		x			x			x					

Closterium sp.					x		x											
Cosmarium contractum										x								
Cosmarium pseudomagnificum														x				
Cosmarium sp.													x		x			
Desmidium aequale			x												x			
Desmidium aptogonum														x				
Desmidium graciliceps									x									
Desmidium grevillii									x		x	x						
Desmidium sp.				x														
Euastrum evolutum										x								
Gonatozygon brebissonii				x						x								
Gonatozygon.taenium										x	x	x			x			
Haplozyga sp.															x			
Hyaloteca dissiliens			x					x	x		x		x		x			
Hyaloteca mucosa								x	x									
Micrasterias alata var. alata										x								
Micrasterias arcuata														x				
Micrasterias furcata			x															
Micrasterias radians				x														
Mougeotia sp					x		x				x			x			x	x
Onychonema filiformis		x																
Pleurotaenium coronatum					x		x											
Pleurotaenium ehrenbergii														x				
Spirogyra columbiana						x												
Spirogyra porticalis						x												
Spirogyra sp.											x			x			x	
Spirogyra varians				x														
Spondylosium pulchrum			x															
Staurastrum artisco			x					x										
Staurastrum sp.										x								
Staurastrum wolleanum		x																
Staurastrum boergesenii		x																
Staurastrum manfeldtii															x			
Staurastrum minnesotense															x			
Staurastrum rotula														x	x			
Staurastrum tentaculiferum														x	x			
Staurastrum hystrix morpha 4-radiata															x			
Xanthidium antilopaeum									x				x		x			
Xanthidium cristatum										x								
Xanthidium sp.															x			

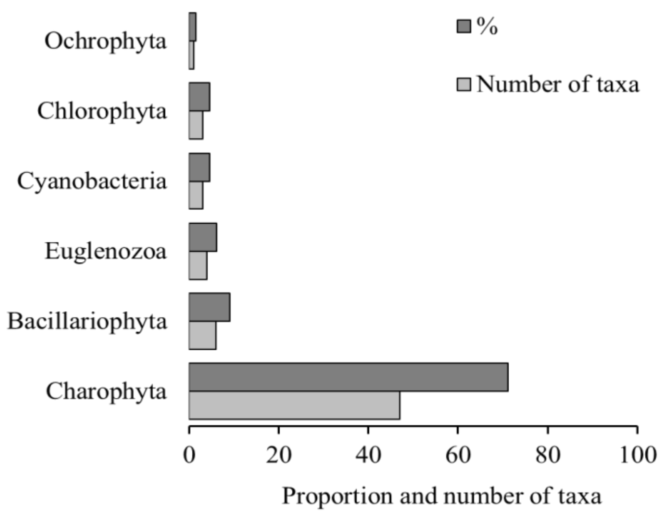
Cells in dark gray represent Sporadic species. Cells in light gray represent Relatively uncommon species. D (dry);
D-R (dry-rainy); R (rainy);
R-D (rainy-dry).
Source: research data.

Figure 3 - Distribution of taxa by taxonomic class (in this order), showing frequencies (grey bars) and absolute values (light bars)



Source: research data.

Figure 4 - Distribution of taxa by taxonomic division (in this order), showing frequencies (grey bars) and absolute values (light bars)



Source: research data.

The phytoplankton composition in the Curiaú River is similar with trends observed in other studies of Amazonian rivers (Aprile; Mera, 2007; Almeida; Melo, 2011, Cunha *et al.*, 2013; Sousa *et al*., 2015). The Zygnematophyceae class (Conjugatophyceae), predominant in this survey, belongs to the group of green algae and is the most diversified class in the Charophyta division (Ramos; Moura, 2023).

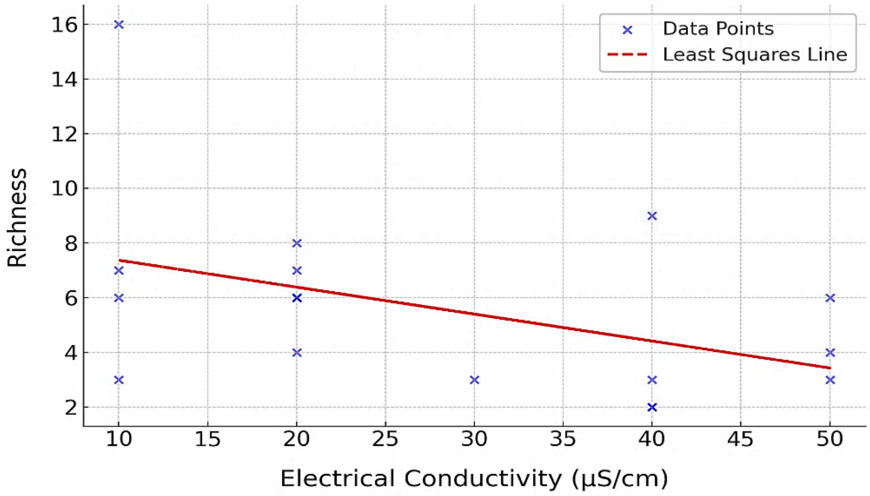
The Charophyta organisms play a crucial role in freshwater aquatic ecosystems, directly impacting the food chain and ecosystem maintenance (Dory *et al.,* 2024; Martins *et al.,* 2024). Desmids, as they are also known, are commonly found in oligotrophic to mesotrophic environments characterized by lentic conditions (Aquino *et al.,* 2018; Criales-Hernández *et al*., 2020; Martins *et al*., 2024), being more prevalent in aquatic environments with acidic waters (Felisberto *et al.* 2014; Stamenković; Hanelt, 2017). This is consistent with the average pH values (5.63 ± 0.61) found in the study area. Desmids represent one of the algae groups with the highest diversity and species frequency in the Amazon region, particularly in blackwater rivers with low electrical conductivity (Melo; Souza, 2009; Souza; Melo, 2011). The presence of this group is often associated with the presence of macrophytes (Felisberto; Rodrigues, 2005; Kahsay *et al*., 2022), as observed in the field.

Regarding the spatial-seasonal dynamics of phytoplankton richness, no significant variations were observed across seasonal periods ($p>0.05$) and between sampling sites ($p>0.05$). Concerning the occurrence frequency, 66% of taxa were classified as sporadic (S), while 34% were considered relatively uncommon (RU) (Table 2). The class Zygnematophyceae (Conjugatophyceae) accounted for most sporadic (43.75%) and infrequent taxa (28.12%).

This result mirrors patterns observed in similar environments. Cunha *et al*. (2013) for instance, noted that in the Falsino and Araguari rivers (AP/Brazil), also located in Eastern Amazon, 69.0% and 25.0% of identified taxa were classified as sporadic and infrequent, respectively. In the Guamá River (PA/Brazil), 60% of microphytoplankton were considered sporadic, followed by infrequent (21.17%), frequent (11.7%), and very frequent (8.2%) (Monteiro *et al*., 2009). Townsed *et al.* (2008) and Martins *et al.* (2024) explain that naturally, most species in their natural ecosystems are considered rare. According to Cunha et al. (2013), only phytoplankton species most adapted to the various hydraulic, limnological, and climatological conditions of a water body will become dominant/frequent in the environment, a phenomenon not observed in this study.

The Spearman rank correlation coefficient test revealed a negative correlation between phytoplankton richness and water electrical conductivity ($r^2=-0.49$; $p<0.05$) (Figure 5). Electrical conductivity (EC) influenced 49% of the variation in phytoplankton richness in the study area. On the other hand, the other variables (DO, pH, temperature, and transparency) did not show significant correlations ($p>0.05$).

Figure 5 - Correlation between phytoplankton richness and electrical conductivity during the sampling period



Source: research data.

Silva *et al.* (2008) suggest that low conductivity values may be associated with high photosynthetic activity (primary production), thus explaining the negative correlation with richness. Similarly, Carneiro et al. (2024) demonstrated in their study a correlation between phytoplankton richness and this variable, associating higher electrical conductivity values with lower richness observed. Moreover, higher conductivity values may be linked to sediment resuspension in water bodies, particularly during the dry season, impacting water transparency and, consequently, the structure of the phytoplankton community (richness and abundance) (Almeida; Melo, 2011). Therefore, electrical conductivity appears to be an important factor at a local scale, influencing community organization during hydrological periods (Moura et al., 2021)

In this research, higher conductivity values were associated with the dry season. Similarly, lower water transparency values and phytoplankton richness were linked to this period. Though water transparency didn't show a significant correlation with phytoplankton richness, reduced light penetration into the water substantially impacts the phytoplankton community structure, leading to a reduction in species richness and consequently, primary production (Bambi et al., 2008).

4 Conclusion

The phytoplankton community in the Curiaú River - an important tributary of the Amazon River - was dominated by desmids, typical of oligotrophic environments with acidic pH and low conductivity. These factors were significantly correlated with phytoplankton richness, underscoring their role in shaping local biodiversity. Most taxes were either rare or sporadic, and their distribution demonstrated homogeneity, with no evident spatial or seasonal variations. Environmental variables, such as temperature, water transparency, pH, dissolved oxygen, and conductivity, were primarily driven by seasonal dynamics, reflecting predictable annual fluctuations. Water transparency exerted a notable influence on other water quality parameters, highlighting the importance of monitoring abiotic conditions to preserve ecological balance. This study contributes to a better understanding of Amazonian phytoplankton biodiversity, providing valuable insights for conservation efforts and informing future research initiatives.

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