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Seasonal Dynamics and Environmental Drivers of Phytoplankton Composition in a Tropical Dam Over 5 Years in Chiang Mai, Thailand

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Abstract

This 5-year study (2015 - 2019) investigates the dynamics of phytoplankton and their correlation with environmental factors including water volume, physicochemical and nutrient availability in Mae Kuang Dam, Northern Thailand. The study identified 177 taxa across 6 groups, with Charophyta being predominant (53.3 %) in both wet and dry seasons, specifically in the genus *Staurastrum*. Taxonomic richness was higher in the wet season, with green algae being the most abundant. In addition, Cyanobacteria, Bacillariophyceae and Chrysophyceae showed increased densities. Annual variations peaked in 2015, decreased in 2017 and exhibited a slight increase thereafter. Cyanobacteria experienced blooms in the wet season, accompanied by significant fluctuations in Charophyta, Cyanophyta, Dinophyta and Euglenophyta. Notably, Cyanophyta exhibited a 20-fold increase from 2015 to 2019. Redundancy Analysis (RDA) highlighted the influence of soluble reactive phosphorus (SRP), conductivity, air temperature, pH, total dissolved solids (TDS) and biochemical oxygen demand (BOD) on phytoplankton during the dry season. Lower water volumes and concentrations of water bodies may intensify the impact of certain factors on phytoplankton communities during this period. In the wet season, pH, conductivity, TDS, ammonia, air temperature and BOD played significant roles, as increased rainfall and nutrient runoff occurred. These results indicate that the combined effects of these environmental variables and hydrological events, including water volume and water static, could influence the dynamics of phytoplankton and water quality. This finding helps us understand the shifts in the aquatic ecosystem under the environmental factors in Thailand. Therefore, further research is needed, emphasizing the necessity for well-planned dam management to maintain both water quality and ecological stability.

Keywords: Mae Kaung Dam, Phytoplankton dynamics, Tropical dam, Long-term monitoring, Community structure, *Staurastrum*

Introduction

Phytoplankton are microscopic single-celled photosynthetic organisms that are crucial to aquatic food webs and contribute significantly to earth's oxygen through photosynthesis. They also play a role in absorbing carbon dioxide, a key factor in global warming [1]. The distribution and composition of phytoplankton vary widely, influenced by environmental factors, including temperature, nutrient availability and light intensity. However, declining water quality, particularly in hot and humid tropical regions, is leading to reduced phytoplankton diversity and the proliferation of harmful algal toxins [2].

In Thailand, a hot and humid climate significantly influences phytoplankton growth [3]. Besides that, the country faces challenges due to water pollution from human activities and climate change impacts [4]. These issues have led to decreased phytoplankton diversity and an increase in toxin-producing plankton [5], adversely affecting aquatic ecosystems and posing health risks. Furthermore, the construction, functionality and hydrological aspects of dams, including factors such as water level, water volume and irrigation, have the potential to disrupt the physical, chemical and biological attributes of water quality, leading to the possible occurrence of algal blooms [2]. Thus, understanding the impact of tropical dam conditions on phytoplankton communities is essential for managing and planning dam conservation to avoid eutrophication, which can worsen water quality. While numerous studies have examined water quality and algal monitoring, reflecting seasonal and environmental variations, most have focused on marine and temperate regions [1,6]. In countries like Thailand, characterized by a hot and humid climate, issues with eutrophication in dams are prevalent. Therefore, our long-term monitoring study aims to fill this gap by focusing on the specific complexities of these freshwater ecosystems, contributing to an improved understanding and providing valuable insights for future management.

This study investigates the environmental factors influencing phytoplankton community dynamics in a tropical dam in Chiang Mai, Thailand, over 5 years from 2015 to 2019. The selected timeframe spans 5 years due to the fluctuating climate and the issue of eutrophication faced in Thailand. This research marks the first long-term monitoring effort of its kind in Thailand's tropical dams. We combined in-situ measurements of temperature, nutrients, light availability and water quality with laboratory analyses of phytoplankton samples, employing multivariate statistical analyses to identify key environmental variables affecting phytoplankton composition and abundance. Understanding phytoplankton dynamics in tropical dams is crucial for assessing the impacts of climate change and pollution. By monitoring these communities over time, we can detect changes indicative of broader ecosystem shifts, aiding in predicting phytoplankton responses to future environmental changes and anticipating harmful algal blooms. This knowledge is particularly relevant for managing the Kuang River's ecosystem. The aims of this study are twofold: 1) To examine the changes in phytoplankton abundance and community composition over 5 years and 2) To investigate the influence of seasonal and environmental factors on these communities during this period.

Materials and methods

This study was conducted at Mae Kuang Dam (18°56'50"N - 99°07'69"E) in Chiang Mai, Northern Thailand, with an altitude of 350 m above sea level. The dam has a catchment area of 569 km^2, a surface water area of 11.8 km^2 and the average water volume of about 203 million m^3. Mae Kuang Dam provides water to an irrigation area of 28,000 hectares and serves as a water source for consumption. Sampling was carried out at the deepest point of the site (18°55'49.3"N 99°07'23.5"E) to observe the abundance and dynamics of phytoplankton [7]. The study covered both the biannual dry and wet seasons, offering a comprehensive understanding of the phytoplankton ecosystem throughout the year [8]. The Mae Kuang Dam map was created using QGIS v3.26.2 (**Figure 1**).

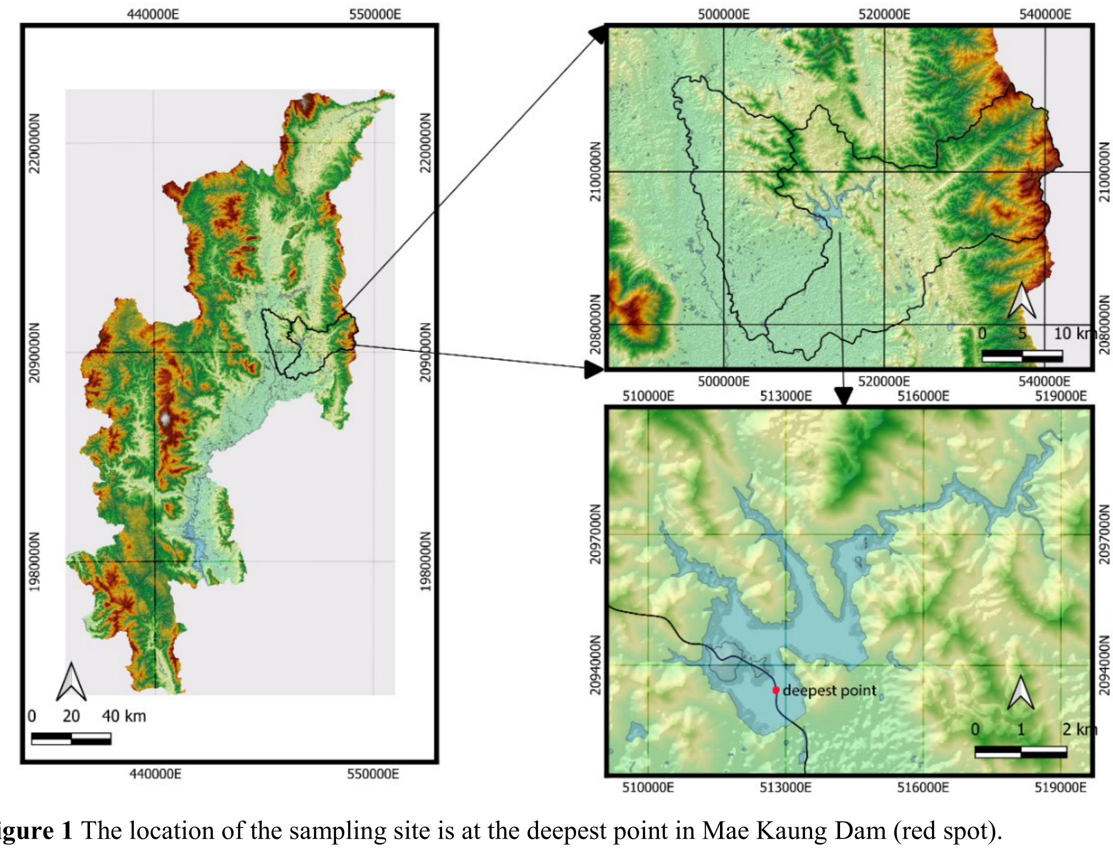

Figure 1 The location of the sampling site is at the deepest point in Mae Kaung Dam (red spot).

Phytoplankton samples were collected semi-annually from 2015 to 2019 during the wet and dry seasons. A Van Dorn bottle was used to collect samples from the surface to the bottom at 5-meter intervals at the deepest point. These samples were then concentrated by direct filtration through a plankton net with a pore diameter of 16 µm mesh and placed in plastic bottles for the determination of qualitative and quantitative composition of phytoplankton. The samples were fixed with neutral Lugol solution, transported to the laboratory and kept in the refrigerator at 4 °C before analysis in the laboratory. For the identification and counting of phytoplankton, a 0.1 mL concentrated sample was classified, identified and counted using a Carl Zeiss Primo Star light microscope with 400× magnification for phytoplankton identification. A taxonomic key was employed to assist in the identification process [9,10].

The water samples were processed using the standard method [11]. In-situ measurements of water temperature, dissolved oxygen (DO), pH and electrical conductivity were taken at 5-meter intervals from the surface to the bottom of the dam using a Horiba multiprobe sensor, model U-22. In the laboratory, nutrient analysis, including nitrate (NO_3^-), was conducted with the Cadmium Reduction Method; ammonia (NH_3) levels were measured using the Nessler Method and soluble reactive phosphate (SRP) was determined through the Phosphomolybdenum Method. Biochemical oxygen demand (BOD) was assessed using the BOD_5 method, and turbidity was analyzed using the Nephelometric Method [11].

The proportion of phytoplankton was assessed by measuring cell densities using a Sedgwick-Rafter counting chamber under a compound microscope, following the methods outlined in APHA, AWWA and WPCP [11]. Simultaneously, the plankton community was characterized by examining taxa richness and abundance, which is measured by the total number of individuals within the plankton community. Relative abundance, measured by the proportion of each species or taxa in relation to the total community abundance, was also analyzed. An independent t-test was performed to test the significance between wet and dry seasons concerning physicochemical parameters [12]. Before conducting comparative analyses, data normality was assessed using the Shapiro-Wilk test. Since both the physicochemical and phytoplankton data exhibited a normal distribution ($p > 0.05$), the parametric test 1-way ANOVA was performed to assess data variability among the years of sampling. In cases where significant differences were detected, post hoc pairwise comparisons were conducted using Tukey's HSD test. If the data did not follow a normal distribution, the non-parametric Kruskal-Wallis test was employed, followed by Dunn's post hoc pairwise comparison [13,14]. Detrended Correspondence Analysis (DCA) was used to determine whether the distribution model was linear or unimodal to test the seasonal and environmental effects on the phytoplankton community. If the length of the first DCA axis was less than 3.5 standard deviations (SD), principal component analysis (PCA) and RDA were performed for ordination [15]. The significance of the multivariate test for homogeneity of group dispersion, RDA and ANOSIM were determined using 999 permutation tests with a significance level of $p = 0.05$. The biotic and abiotic data, except pH, were transformed as ln (x + 1) to reduce the effects of extreme values [16]. The analyses used the R program 3.3.2 (R Core Team, 2021) including packages, vegan, tidyverse and ggplot2.

Results and discussion

During the study period from 2015 to 2019, the precipitation at Mae Kaung Dam ranged from 831.8 to 1419.6 mm, with the lowest recorded in 2015 and the highest in 2017. Synchronized with the water volume, which ranged from 654.5 to 1476.6 million m^3, the lowest was observed in 2015 and the highest occurred in 2018 (**Figure 2**). This event can be described as in 2015, both precipitation and water volume reached their lowest points, indicating a period of reduced rainfall and subsequent impact on the dam's water storage. Subsequently, in 2017, the precipitation peaked at 1,419.6 mm, accompanied by a rise in water volume, suggesting a year of increased rainfall and improved dam storage. Furthermore, in 2018, although precipitation did not reach the maximum recorded in 2017, the water volume achieved its highest point. This discrepancy suggests a delayed response in water volume to the previous year's precipitation, possibly due to factors such as delayed runoff or changes in water release patterns.

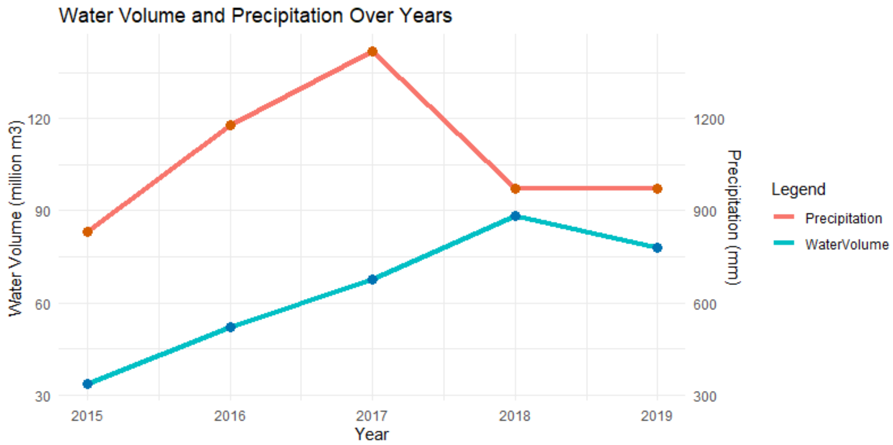

Figure 2 Precipitation and water volume in Mae Kaung Dam during 2015 to 2019.

Environmental variables

Throughout our study at Mae Kaung Dam, we observed changes in various physical and chemical factors. The average and standard deviation are following air temperature was 30.2 (± 1.96) °C, peaking in 2017 at 33 °C, while the average water temperature was 26.3 (± 2.81) °C, reaching its highest point in 2019 at 31 °C. The mean pH level measured was 7.21 (± 0.75), with a maximum of 9.30. Conductivity was 93.8 (± 22.01) µS/cm, with the highest level detected in the wet season of 2015 at 175 µS/cm. Turbidity averaged 14.13 (± 12.86) NTU, with the maximum value recorded at 60 NTU in 2015. DO measured 2.48 (± 3.17) mg/L, with the maximum value found at the surface water being 8.41 mg/L. Ammonia measured 0.42 (± 0.52) mg/L, reaching a high of 2.43 mg/L in 2017, and nitrate was at 0.61 (± 0.44) mg/L, with the highest value observed in 2017 at 2.20 mg/L. Importantly, no significant differences were observed among the years ($p > 0.05$). On the other hand, only 2 parameters including SRP and TDS significantly varied across the years ($p < 0.05$) (**Figure 3(a)**). SRP is a form of phosphorus that is readily available for uptake and utilization by phytoplankton. In aquatic environments, phosphorus is a crucial nutrient for the growth and development of phytoplankton. The high levels of SRP can potentially lead to increased growth and reproduction, contributing to the formation of algal blooms [17]. TDS represents the concentration of inorganic and organic substances dissolved in water. Extreme or imbalanced concentrations can affect phytoplankton growth and overall ecological dynamics [18]. SRP had a mean value of 0.15 (± 0.14) mg/L with the highest value recorded at 0.66 mg/L in the wet season of 2019, while TDS averaged 74.69 (± 24.12) mg/L with the peak value occurring in the wet season of 2015 at 150 mg/L. These variations highlight specific changes in water quality, offering valuable insights into the environmental dynamics of Mae Kaung Dam. Regarding physicochemical variations among seasons in Mae Kaung Dam, the results showed that 4 parameters exhibited a significant difference ($p < 0.05$) between seasons. BOD values in the dry season were higher than in the wet season, while water temperature, conductivity and TDS values in the wet season were higher than in the dry season (**Figure 3(b)**). According to the results, the dry season, lower water volume and reduced flow may lead to increased organic matter concentration in the water. This heightened organic load, combined with limited dilution due to lower water levels, can result in higher BOD levels [19]. While SRP and TDS were significantly higher in the wet season, this can be explained by the fact that phosphorus, in its soluble form, originates from both non-point sources, including diffuse sources spread across the area around the dam and point sources such as restaurants near the dam [20]. During the wet season, increased rainfall can lead to enhanced runoff from the surrounding land, carrying soil particles that are rich in phosphorus. This process results in elevated levels of SRP and increased turbidity in the wet season.

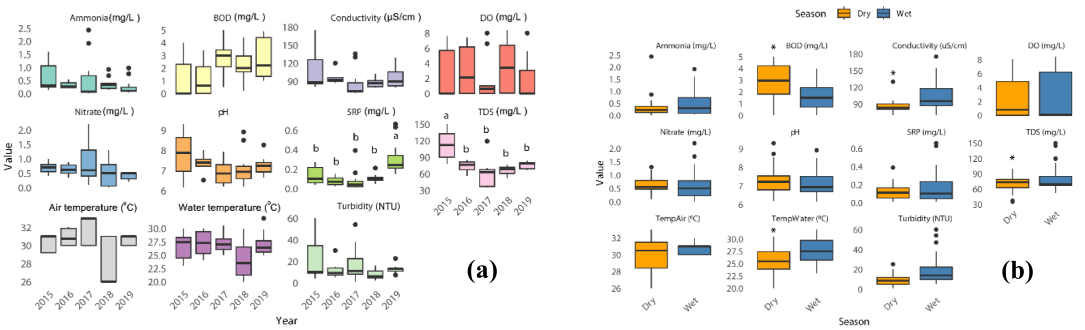

Figure 3 The boxplot illustrates the physicochemical parameters of Mae Kuang Dam: (a) Comparison of the average physicochemical parameters in different years from 2015 to 2019. Different letters indicate significant differences ($p < 0.05$). (b) Comparison of the average physicochemical parameters in dry and wet seasons during 2015 - 2019 (* indicates significant differences).

Phytoplankton

A total of 177 taxa from 61 genera belonging to 6 major phytoplankton groups were identified during the wet and dry seasons from 2015 to 2019. Specifically, 68 species in Charophyta, 46 species across 20 genera in Chlorophyta and 17 species within 12 genera in Cyanophyta were recorded. Charophyta exhibited the highest percentage of cell density (53.3 %), followed by Chlorophyta (19 %) and Cyanophyta (10 %). Overall, taxonomic richness was greater in the wet season compared to the dry season throughout the years 2015 - 2019 (**Table 1**).

Table 1 Overall phytoplankton composition at Mae Kuang Dam between 2015 - 2019 in wet and dry season.

Group	No. of genus		No. of taxa		Density	Proportion (%)		
	Wet	Dry	Wet	Dry	(Cells/L)	Wet	Dry	Total
Charophyta	11	9	60	58	1,467,335	48.19	61.36	53.44
Chlorophyta	20	18	43	34	512,730	18.03	19.65	18.67
Cyanophyta	11	8	13	13	285,841	11.81	8.33	10.45
Dinophyta	4	4	8	8	182,772	9.60	2.26	6.65
Euglenophyta	3	3	14	9	134,542	5.05	4.67	4.90
Heterokontophyta								
Bacillariophyceae	5	3	6	4	78,104	2.93	2.71	2.84
Xanthophyceae	2	2	6	3	8,100	3.60	0.53	2.37
Eustigamophyceae	1	-	1	-	1,700	0.10	-	0.06
Chrysophyceae	1	1	3	1	7,000	0.18	0.46	0.29
Synurophyceae	1	-	1	-	65,136	0.46	-	0.28

The overall cell density of phytoplankton is higher and more diverse in the wet season compared to the dry season. However, the green algae Charophyta and Chlorophyta are more abundant in the dry season than in the wet season. This can be explained by the fact that in tropical regions such as Thailand, the distinct dry and wet seasons, characterized by consistently warm to hot temperatures throughout the year, play a significant role in the occurrence of algae blooms [21,22]. Warmer water temperatures can accelerate the metabolic rates of phytoplankton, leading to increased growth and reproduction [23]. Particularly during the wet season, there is a sudden surge in nutrients. Water discharge from land and urban areas may alter ambient nutrient regimes, resulting in changes in the phytoplankton community composition [20]. This makes Mae Kaung Dam conducive to algae blooms during the wet season.

Regarding the trends in phytoplankton density at Mae Kuang Dam from 2015 to 2019, fluctuations in density were observed. The highest cell density was recorded in 2015 and dropped in the year 2017 (**Figure**

4(a)). Significance tests revealed that the green algae Charophyta (F = 5.461, $p < 0.001$), Cyanophyta (F = 6.482, $p < 0.001$), Dinophyta (F = 2.784, $p < 0.05$) and Euglenophyta (F = 4.061, $p < 0.05$) exhibited significant changes in numbers. Notably, green algae showed a substantial decrease in numbers from 5×105 to 1.9×105 Cells/L^2, representing an almost 2.5-fold decrease (**Figure 4(b)**). This trend was similar for Dinophyta and Euglenophyta, which displayed high numbers in 2015 and a gradual decline over the years. This decline can be explained by the low water volume in 2015 due to a drought event in Thailand, with rainfall slightly accumulating until 2017. In 2017, the water volume reached its highest peak, being a flooding year with a significant water volume during the rainfall, leading to a drop in the cell density of phytoplankton. This observation is supported by Costa *et al.* [17], who proposed that the phytoplankton functional structure changes on a temporal scale due to water volume fluctuations induced by rainfall patterns. High water volume appears to improve water quality and dilute allochthonous and the cell density of phytoplankton. However, the data interestingly show that the number of Cyanophyta increased from 7,180 to 1.4×105 Cells/L^2, an almost 20-fold increase (**Figure 4(b)**). These results highlight that Cyanophyta numbers increased significantly over time, leading to the consideration that elevated SRP levels in the water may result in eutrophication or algae blooms. The observed cell density of the Cyanophyta bloom coincided with the high SRP value in 2019. However, these findings prompt further discussion about the long-term dominance of the Cyanobacteria group in nitrogen-limited waters, potentially altering nitrogen cycling [24,25].

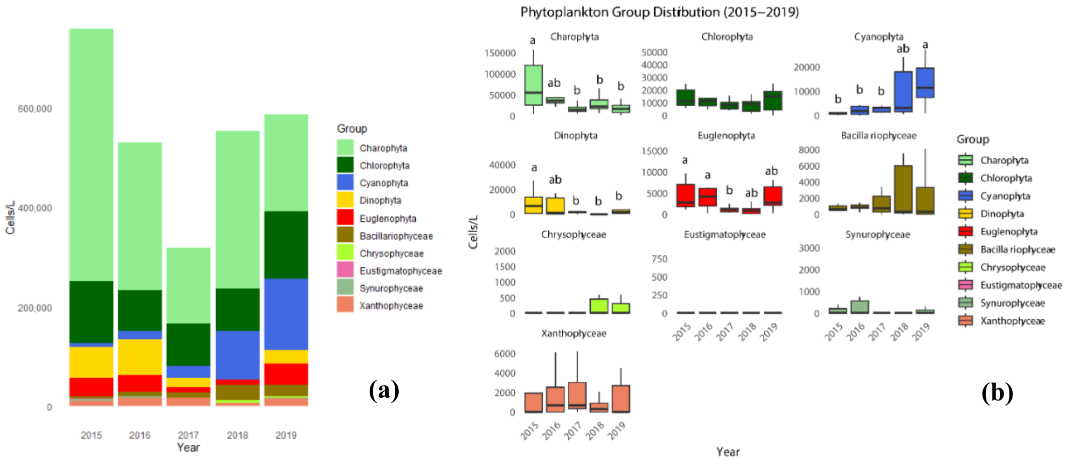

Figure 4 (a) Phytoplankton group distribution in overall and (b) Phytoplankton group distribution 2015 - 2019 in each year. Different letters indicate significant differences ($p < 0.05$).

To investigate the effects of seasonal variation on phytoplankton composition, we observed the community at the genus level at different depths during both the wet and dry seasons. The results revealed that, overall, the green algae in the genera *Staurastrum* and *Cosmarium* were the most prominent contributors in Mae Kaung Dam, while other genera showed fluctuating variations among seasons. Both *Staurastrum* and *Cosmarium* are green algae belonging to Chlorophyta and Charophyta, respectively, often found in freshwater habitats such as ponds and lakes. They are adapted to a wide range of environmental conditions within these habitats [26,27]. As they resemble higher plants and involve multicellular haploid and diploid phases, setting them apart from other algae groups. This differentiation in features and biological traits leads to varied explanations for their behavior and prevalence in different environmental conditions compared to other algae groups [28-30].

In the dry season, 28 major genera were present, with green algae (both Chlorophyta and Charophyta) dominating throughout the years 2015 - 2019. However, Cyanophyta showed an increasing dominance in the dry season, while green algae exhibited a decreasing trend (**Figure 5**). Specifically, during the dry season of 2019, Cyanophyta genera such as *Anabaena* and *Chroococcus* were highly prominent. Additionally, Euglenophyta and Bacillariophyceae were more prominent in 2019 compared to other years. During the wet season, the number of phytoplankton genera increased from 28 to 39, and new groups such as Synurophyceae and Eustigmatophyceae were identified. Dinophyta and Charophyta groups were equally dominant in 2015 and 2016, particularly *Ceratium*. This genus bloomed only from 2015 to 2016 but declined in the 3 years following our observation. Our observations indicate that these shifts may be attributed to changes in environmental conditions, including variations in water quality, nutrient levels and possibly hydrological factors. This finding is supported by Li *et al*. [31], stated that changes in water volume might affect nutrient concentrations. In this condition, green algae or Cyanobacteria are favored by the increased nutrient levels and *Ceratium* may face competition, impacting its cell numbers. Thus, not surprisingly, in our findings, Cyanobacteria, including *Aphanizomenon*, *Anabaena* and *Chroococcus*, replaced it in the later years (**Figure 5**). However, over the entire 5-year period, the relative abundance of the green algae group remained higher than that of the others. According to the results, the dynamics of green algae in both the dry and wet seasons show a decreasing trend year by year, even though they exhibit high numbers throughout the sampling period, while Cyanophyta exhibits an increasing trend over the past 3 years. Particularly in 2019, our results can be explained by the high SRP in 2019 (**Figure 2(a)**), leading to a low N/P ratio, which may favor the growth of cyanobacteria. This finding is supported by the report of Li *et al.* [31], stating that cyanobacteria easily form under low N/P ratio conditions. However, the N/P ratio is not perfect for explaining the dynamics of phytoplankton under different water quality conditions. Additional observations, as reported by Litchman *et al.* [32], who noted that green algae trends are expected to decrease over time, giving way to the dominance of Cyanobacteria due to increased environmental stressors. Cyanobacteria possess a competitive advantage in surviving extreme conditions compared to other organisms. Importantly, prior studies support our results, emphasizing the prevalence of Cyanobacteria. Their abundance varies with depth and increases over time, particularly during the wet season. The number of phytoplankton taxa is higher in the wet season. Cyanobacteria, known for producing toxins, can adversely affect water quality, rendering it unsuitable for consumption and contributing to poor water quality. Numerous reports suggest that Cyanobacteria thrive in conditions with high nutrient levels, warm temperatures and intense light [25,33].

The relationship between phytoplankton and environmental variables on seasonal variability

RDA is a multivariate technique used to explore how various environmental variables influence the composition of plankton communities in a water body. It is valuable for identifying and quantifying the major environmental gradients that explain variations in species composition. We aim to address questions about the distribution of phytoplankton at the group and genus levels with environmental factors and determine the main driving factors influencing plankton communities.

The RDA model in the dry season has a significant effect (F = 3.3437, p = 0.001) on the group of phytoplankton and can explain 83.73 % of the observed variation. The first 2 RDA axes were also significant (p < 0.01) and can explain 54.64 and 17.22 %, respectively. The environmental variables that significantly influenced the phytoplankton groups included SRP, conductivity, air temperature, pH, TDS and BOD (**Figure 6(a)**). Charophyta were influenced by DO, pH, and water temperature, while Cyanobacteria and Bacillariophyceae responded to depth, BOD, turbidity, air temperature and SRP (**Figure 6(a)**).

In the wet season, the RDA model was significant (F = 3.91, p = 0.001), and the environmental variables explained 83.9 % of the variation in phytoplankton group composition. The first 2 RDA axes were also significant (p < 0.01) and could explain 52 and 15.51 %, respectively. The environmental variables that significantly influenced the phytoplankton community included pH, conductivity, TDS, ammonia, air temperature and BOD. The phytoplankton community responded differently; Bacillariophyceae and Charophyta were driven by air temperature and pH, while Cyanophyta related to BOD and SRP. Dinophyta is strongly related to TDS and turbidity (**Figure 6(b)**).

Upon closer inspection at the genus level and environmental parameters, the RDA model for the dry season is statistically significant (F = 3.778, p = 0.001) and explains 80.4 % of the variation in the phytoplankton community. The first 2 axes are also significant (p = 0.001), explaining 37.2 and 15.06 %, respectively. The RDA model reveals that depth, air temperature, water temperature, pH, conductivity, TDS and BOD are significant factors influencing the phytoplankton data, while the other variables do not contribute significantly. The response of *Staurastrum*, *Tetraedron* and *Botryococcus* is associated with pH, TDS, conductivity and water temperature, while *Asterococcus* and *Chroococcus* are related to BOD and depth (**Figure 6(c)**).

The RDA model predicting the responses of phytoplankton composition at the genus level in the wet season revealed that the environmental variables explained 84.2 %, with statistical significance (F = 3.998, p = 0.001). The first 2 axes are significant (p = 0.001), explaining 30.29 and 23.74 %, respectively. Air temperature, pH, conductivity, SRP, ammonia, TDS, water temperature, BOD and nitrate were significant factors in this regime. *Ceratium*, *Pediastrum* and *Aphanizomenon* are related to air temperature and TDS, while *Anabeana* and *Chroococcidoopsis* are related to SRP (**Figure 6(d)**).

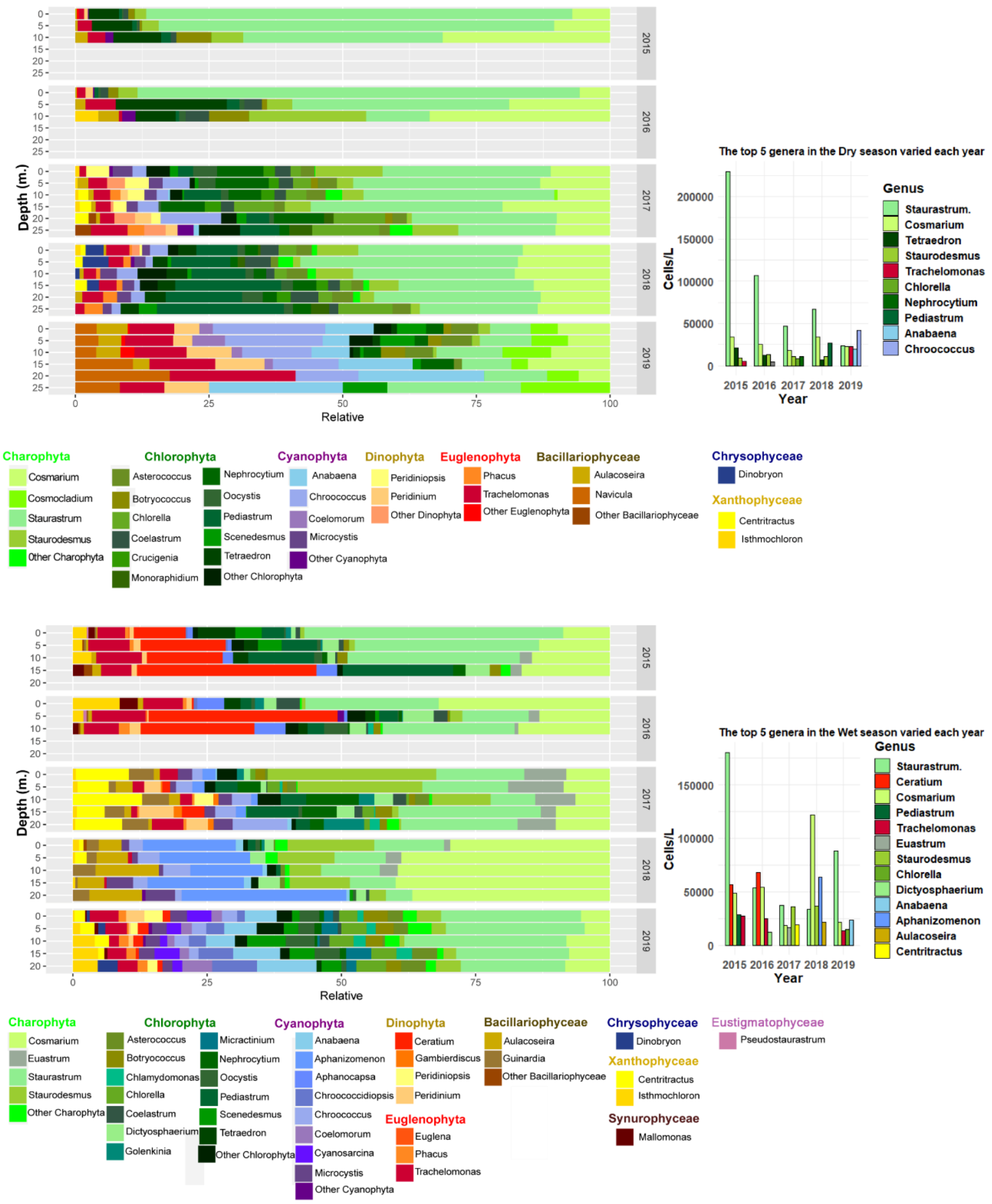

Figure 5 The relative contribution of the total abundance of the phytoplankton assemblages and the dominant in genera in each seasonal period along the different depths of the 5 years studied.

From our data demonstrate that the model significantly influences phytoplankton groups and genera. However, changes in the phytoplankton community in aquatic bodies during seasonal variations are complex, as they are influenced by numerous factors in realistic regimes [34]. Particularly in the dam, where the water body is constantly disturbed by input and output water, and the characteristics of the catchment area result in differences and complexity in water quality. In this study, it is evident that the phytoplankton community responds differently in wet and dry seasons, with the dominant environmental factors varying between seasons. Key influencers identified include air temperature, pH, turbidity, TDS, biological oxygen demand (BOD), ammonia, water temperature, nitrate and SRP. Algae respond to these parameters, such as *Anabaena* and *Cosmodladium* related to SRP, *Asterococcus* and *Chroococcus* responding to BOD and *Ceratium* responding to turbidity. Previous studies report that these algae are well-adapted groups and can tolerate environmental factor deficiencies more successfully than less adapted species, and the abundance of algae represents eutrophic water [35,36]. Therefore, the presence of this group is not conducive to good water quality in the dam, leading to a deterioration in water quality. This study implies that the fundamental necessities for the growth of phytoplankton involve nutrients and temperature. Additionally, hydrological factors such as water static, water volume, TDS and turbidity might influence the selection of phytoplankton groups. These results are supported by Li *et al.* [31] , who reported that the factors influencing the dynamics of phytoplankton are complex, as the dominant competition could be determined by multiple environmental factors rather than a single one.

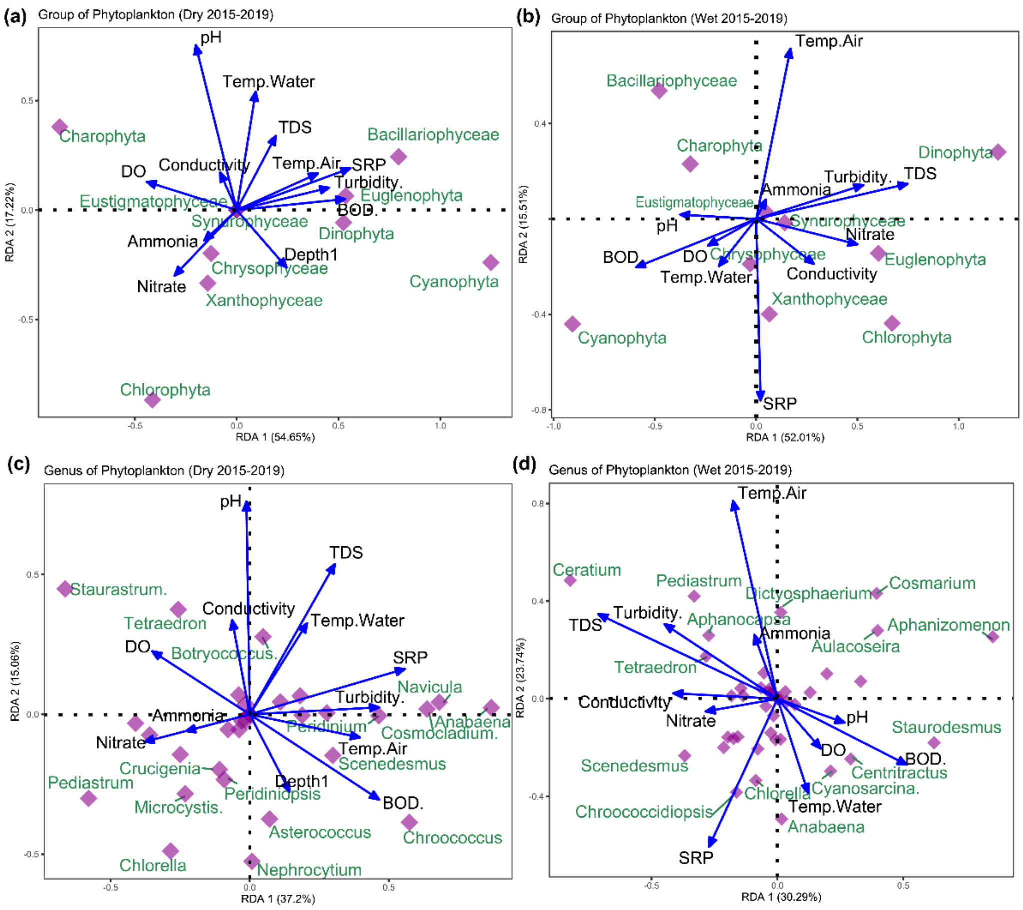

Figure 6 RDA showing the environmental variable and phytoplankton variation from Mae Kaung Dam, plotted relative to the significant environmental variables (a) group of phytoplankton in Dry season; (b) group of phytoplankton in Wet season; (c) genus of phytoplankton in Dry season, and (d) genus of phytoplankton in Wet season.

Conclusions

Based on our 5-year monitoring of phytoplankton and environmental variables at Mae Kuang Dam, one of the largest and most important dams in Northern Thailand, our results indicate that hydrological variability, such as extreme rainfall events, can directly impact water volume fluctuations in the freshwater ecosystem. This alteration affects environmental variables, including physical and chemical properties, as well as nutrient variability in the water, and indirectly influences phytoplankton dynamics. During the wet season, there was an increased number of algae, with the Cyanophyta group being prominent due to elevated temperature and high nutrient loading, leading to cyanobacteria blooms. The temporal dynamics show a decrease in green algae over the years, while Cyanobacteria increased 2 years later when the water volume became slightly static in the dam. Therefore, there is a need to closely monitor the dam, regulate water flow and velocity to avoid water stratification, and prevent the growth of toxin-producing algae. These findings underscore the importance of monitoring and implementing effective management strategies for Mae Kuang Dam. Management efforts should particularly focus on controlling nutrient inputs, especially during the wet season, to mitigate the risks of eutrophication and cyanobacteria proliferation.

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