Phytoplankton composition and diversity in Lake Tikub, Tiaong, Quezon, Philippines

Nerissa K. Torreta*[1], Jeremaiah L. Estrada[2], Paul John F. Flores[2] and Noel G. Sabino[3]

[1]Plant Biology Division, Institute of Biological Sciences, College of Ars and Sciences, University of the Philippines Los Baños, College, Laguna, Philippines
[2]Graduate School, University of the Philippines Los Baños, College, Laguna, Philippines
[3]Microbiology Division, Institute of Biological Sciences, College of Arts and Sciences, University of the Philippines Los Baños, College, Laguna, Philippines

A study was conducted in Lake Tikub, Tiaong, Quezon, Philippines to determine its phytoplankton composition and diversity. Four abiotic parameters including chemical parameters (water pH, and dissolved oxygen) and physical parameters (surface water temperature and limit of visibility) were measured. Phytoplankton composition and diversity were assessed based on identification, cell counts and chlorophyll a determination. Trophic state index (TSI) was also computed based on the chlorophyll a content and Secchi Disk depth values. The lake was classified according to the traditional trophic state denomination based on the results for the computation of TSI. A total of 21 taxa, identified to the genus level, were observed in the euphotic zones of Lake Tikub which belonged to four major phytoplankton groups: diatoms, green algae, cyanobacteria and dinoflagellates. Among the 21 identified species, green algae were the richest group with 10 species, followed by diatoms (8 species) and cyanobacteria (2 species). Dinoflagellates had only one representative species. Diatoms and green algae were the most abundant phytoplankton groups in Lake Tikub. Algae are affected by physico-chemical parameters that could be the determining factor of their community structure in Lake Tikub. Trophic state index (TSI) of the lake in terms of water quality and chlorophyll *a* concentration showed a positive result classifying it as oligotrophic and mesoeutrophic. Based on the data gathered, the lake can sustain life, but further studies must be done to learn more about Tikub Lake.

*Corresponding author
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INTRODUCTION

Aquatic ecosystems like lakes are rich environments in terms of life forms and composition (Carboni 2006) supporting phytoplankton growth through cycling of matter and energy from chemical-biological processes. Freshwater phytoplankton can be extremely diverse in terms of taxonomy, morphology and ecology (Prescott et al. 1978; Bellinger and Sigee 2010). They can respond to a wide range of pollutants making them useful in providing early warning signals of deteriorating conditions and the potential causes of such conditions (Lacuna et al. 2012). Factors that determine the structure of phytoplankton communities in lakes include the interplay between the effect of chemical, physical and biological parameters (Basualto et al. 2006). Thus, all these factors play an important role in determining which phytoplankton species can thrive or die in a particular lake.

Physico-chemical parameters and their effect in the production of phytoplankton in water bodies are considered very important in designing management strategies for aquatic ecosystems (Edward and Ugwumba 2010). Using bioindicators and physico-chemical parameters, lakes and other water bodies can be tested for aesthetic, recreational, industrial, domestic or agricultural purposes. Likewise, these data can also help determine the health status of the system.

The Philippines is home to many aquatic ecosystems. Several freshwater lakes exist in the Southern part of Luzon. Among them is Tikub Lake, located in the town of Tiaong, province of Quezon. Tikub Lake is a landlocked crater lake nestled at the foot of Mt. Malepunyo which is shared and bordered by Barangay Ayusan I and Barangay San Pedro in Tiaong, Quezon (Labatos and Briones 2014). Lake Tikub is a maar or a low-profile volcano created by phreatomagmatic eruption or the interaction between groundwater and magma underneath the Earth's surface. Like the seven lakes in the city of San Pablo, Laguna, which is about 15 kilometers (9.3 miles) away, the lake is one of the monogenetic volcanoes located in the Southwestern Luzon Volcanic field (Wernstedt and Spenser 1967). Tikub lake is home to nine species from seven families of fish (Labatos and Briones 2014). The lake was earmarked for tourism development since the early 2000s and is being managed by the local government in association with the community living within its vicinity (Brillo et al. 2017).

Table 1: List of the stations of collection showing the GPS location (latitude and longitude) and water resource use

Stations	Global Positioning System (GPS) Location	Water Resource Use
1A	13° 57' 40" N 121° 18' 29" E	Tilapia aquaculture
1B	13° 57' 38" N 121° 18' 28" E	Tilapia aquaculture
2A	13° 57' 53" N 121° 18' 27" E	Tilapia aquaculture
2B	13° 57' 49" N 121° 18' 29" E	Tilapia aquaculture
3A	13° 57' 54" N 121° 18' 18" E	Navigation and subsistence fishing
3B	13° 57' 49" N 121° 18' 15" E	Navigation and subsistence fishing
4A	13° 57' 42" N 121° 18' 16" E	Navigation and subsistence fishing
4B	13° 57' 39" N 121° 18' 19" E	Navigation and subsistence fishing
C	13° 57' 46" N 121° 18' 23" E	Navigation and subsistence fishing

Figure 1: Lake Tikub, Tiaong, Quezon, Philippines

Little is known about the algal community profile and the productivity of this lake. Thus, this study was conducted to assess the composition and diversity of phytoplankton in Lake Tikub and to know the physico-chemical parameters that determine its phytoplankton community structure.

MATERIALS AND METHODS

Site Description

This study was conducted in Lake Tikub, a near-perfect circular caldera lake in Barangay San Pedro, Tiaong, Quezon, Philippines with coordinates 13°57'45.81" N, 121°18'22.95" E at the center (Figure 1). It is situated at the slope of Mt. Malepunyo, one of the three peaks of the Mt. Malarayat Mountain Range. The lake has a surface area of 48.34 hectares (Labatos and Briones 2014). The circumference of Tikub lake is elevated and thick with foliage that steeply slopes down to the shore. The lake does not have inlets or outlets and is replenished by rainfall and surface runoff while it discharges through seepage and evaporation (Brillo et al. 2017).

Tikub lake had been utilized for subsistence fishing and tilapia aquaculture (Brillo et al. 2017). There are floating tilapia fish cages which are being maintained by residents of Barangay San Pedro. The lake is also being used to a limited extent, for recreation and tourism (Labatos and Briones 2014).Tourism-oriented activities such as paving the main roadway and entry steps to the lake, cementing the access road linking the lake to the national highway, establishing a wide trail and reforesting the vicinity of Tikub lake were done by the local government (Brillo et al. 2017).

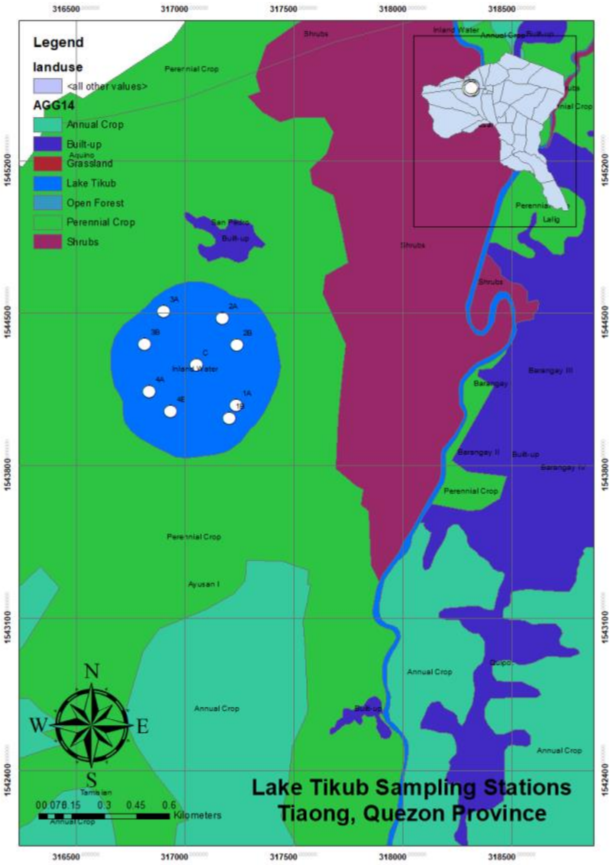

Figure 2: Map showing the nine sampling stations in Lake Tikub, Tiaong, Quezon, Philippines generated using ArcGIS 10.4

Sampling Points

A total of nine sites in Lake Tikub were designated as sampling stations and their coordinates were determined using a Garmin™ Rhino 610 mobile GPS. Eight of these sampling points were about 20 m away from the shore and encompassed the entire circumference of the lake. The ninth sampling station was located at the center of the lake (Table 1; Figure 2). The first four sampling points were situated near Tilapia fish cages while the remaining points were in areas of the lake which are being used for subsistence fishing, navigation and recreation.

Physico-chemical Parameters Measurement
Abiotic parameters were considered in the study, including chemical parameters (water pH and dissolved oxygen concentration) and physical parameters (surface water temperature and limit of visibility). Surface water temperature and water pH were determined using a Horiba U-10 Water Quality Checker. Dissolved oxygen (DO) was measured using a DO meter (Starter 300D, OHAUS). The method in measuring these parameters using probes was described by EMB (2008). The Secchi disk (Geo Scientific Ltd) was employed in determining limit of visibility and depth of the euphotic zones. Other physical factors like weather condition (temperature and rainfall) were noted during sampling. The resource uses within and near the sampling stations were recorded and documented.

Table 2: Mean values of the physical and chemical parameters at the nine sampling sites in Lake Tikub during October, 2018 and November, 2018 sampling

October									
Parameters	Stations								
	1A	1B	2A	2B	3A	3B	4A	4B	C
Temperature (^oC)	31.6	31.9	31.57	31.9	32.5	32.63	32.27	32.1	32.63
Limit of visibility (m)	3.89	4.16	4.38	4.20	4.62	4.71	3.48	2.93	4.68
pH	9.08	8.89	8.52	8.73	8.79	8.64	8.65	8.6	8.63
Dissolved Oxygen (mg/L)	5.57	5.6	5.67	5.77	5.2	5.4	5.2	5.17	5.4
November									
Parameters	Stations								
	1A	1B	2A	2B	3A	3B	4A	4B	C
Temperature (^oC)	30.1	30.27	30.53	30.2	30.9	30.13	30.5	30.23	30.8
Limit of visibility (m)	4.1	4.57	4.67	4.85	4.48	4.48	4.55	4.53	4.70
pH	7.86	8.1	7.85	8.3	8.4	7.92	8	8.08	8.27
Dissolved Oxygen (mg/L)	6.03	5.47	5.49	5.32	5.33	5.6	5.72	5.53	5.3

Phytoplankton Sampling
Phytoplankton sampling was performed from 8am to 2pm in October and November, 2018. For each sampling station, samples of equal volume were obtained by lowering a Wildco 8" Student Plankton Net Sampler to a depth of one meter below the euphotic zone (EMB 2008). Vertical and horizontal sampling methods were performed. A total of 1050 ml from the composite sample (three replicates) per zone was filtered using a plankton net (23-micron mesh size) to obtain a 100 ml subsample. The collected subsamples were then transferred to individual clean bottles. Lugol's solution was used to preserve the phytoplankton samples. The filtered phytoplankton sample (100 ml) was transferred to a graduated cylinder and allowed to settle for 24 hours. The upper 90 ml was gently siphoned off, leaving the concentrated phytoplankton at the bottom.

Cell Counting and Identification
Concentrated 10 ml sample was transferred to a vial, where 10 µl was obtained for cell counting using an improved Neubauer haemocytometer (Tiefe-Depth Profondeur 0.100 mm; BLAU, Germany). Phytoplankton species were identified using available literature and identification keys (Lee 2008; Prescott et al. 1978). Phytoplankton pictures were taken using a ZEISS axioscope which aided in confirming taxonomic identification of the specimens.

Chlorophyll *a* Determination
Analysis of algal chlorophyll a was done using 1050ml of water sample filtered and concentrated using a GFC filter paper and a hand pump during the field sampling. Chlorophyll extraction was done using 90% acetone while chlorophyll content was spectrophotometrically determined using a Shimadzu UV Mini 1240 spectrophotometer and calculated in µg chl ml^{-1}. Mixed phytoplankton populations containing chl *a* (in 90% acetone) was computed using the formula below (Jeffrey and Humphrey 1975).

$$\text{chl } a = 11.85\ A_{664} - 1.54\ A_{647} - 0.08\ A_{630}$$

Computation for Phytoplankton Community Structure and Trophic State Index (TSI)
Cell abundance was analyzed to determine the population of plankton found in an area. The average values of phytoplankton counts using the haemocytometer was taken into account for calculating density. The formula below was used (Provost 2012; Strober 2001).

Equation 1: $n \times df \times 10^4$
Where n: Average number of cells in one large square; df: average dilution factor

Species richness was determined by getting the total number of species present in each sampling month. Comparison of richness between months was done using the Index of Similarity (Simpson 1949). The ecological indices that were generated include Shannon-Wiener Index of General Diversity, Index of Dominance, Index of Similarity and Evenness Index using Paleontological Statistics Software (PAST).

Trophic state index (TSI) is a classification system designed to rate bodies of water based on the amount of biological activity they sustain (LCWA n.d.). The TSI of a body of water is rated on a scale from 0 to 100. Under the TSI scale, bodies of water may be defined as:

- **Oligotrophic** (TSI 0-40, having the least amount of biological productivity, "good" water quality);
- **Mesoeutrophic** (TSI 40-60, having a moderate level of biological activity, "fair" water quality); or
- **Eutrophic to hypereutrophic** (TSI 60-100, having the highest amount of biological activity, "poor" water quality)

Calculations of TSI utilizing lake turbidity specifically the Secchi disk depth (meters) and values obtained for chlorophyll a were done using the formulas cited by Fuller and Jodoin (2016) which are given as follows:

$$\text{TSI (SD)} = 60 - 14.41[\ln(\text{SD values})]$$
$$\text{TSI (Chl a)} = 9.81[\ln(\text{chl } \mu g/L)] + 30.6$$

RESULTS AND DISCUSSION

Tiaong, Quezon where Tikub lake is situated, falls under Type IV climate based on the Modified Corona Classification of Climate. It is characterized as having rainfall which is more or less evenly distributed throughout the year. Generally, high levels of precipitation are observed during the months of October and November (Climate-Data.org. n.d.).

Temporal and spatial variations were recorded for the physico-chemical parameters of the lake throughout the study (Table 2).

The parameter readings that have decreased in November were temperature and pH levels. Specific values gathered for the said parameters in October for all stations however, were above the standard values of 6.5-8.5 for pH and 26-31 $_{o}$C for temperature set by the Department of Environment and Natural Resources – Dept. Administrative Order (DENR-DAO 34 1990) for a Class B surface water body in which Lake Tikub had been classified (EMB n.d.). Meanwhile, the DO values obtained during the two sampling periods were higher than the minimum standard of 5 mg/L. The depth of the euphotic zone in all the sampling sites, on the other hand, ranged from 3.06 to 4.95m.

Table 3: List and taxonomic classification of identified phytoplankton species in Lake Tikub, Tiaong, Quezon in the month of October, 2018 (Lee 2008 taxonomic scheme)

Division	Class	Order	Family	Genera
Chlorophyta	Chlorophyceae	Sphaeropleales	Selenastraceae	*Ankistrodesmus*
Pyrrophyta	Dinophyceae	Gonyaulacale	Ceratiaceae	*Ceratium*
Chlorophyta	Chlorophyceae	Chlamydomonales	Volvocaceae	*Pandorina*
Bacillariophyta	Bacillariophyceae	Cocconeidales	Cocconeidaceae	*Cocconeis*
Bacillariophyta	Bacillariophyceae	Cymbellales	Cymbellaceae	*Cymbella*
Bacillariophyta	Bacillariophyceae	Tabellariales	Tabellariaceae	*Diatoma*
Chlorophyta	Trebouxiophyceae	Chlorellales	Chlorellaceae	*Dictyosphaerium*
Chlorophyta	Chlorophyceae	Chlamydomonales	Volvocaceae	*Eudorina*
Bacillariophyta	Coscinodiscophyceae	Melosirales	Melosiraceae	*Melosira*
Bacillariophyta	Bacillariophyceae	Naviculales	Naviculaceae	*Navicula*
Cyanobacteria	Cyanophyceae	Oscillatoriales	Oscillatoriaceae	*Oscillatoria*
Chlorophyta	Chlorophyceae	Sphaeropleales	Hydrodictyaceae	*Pediastrum simplex*
Chlorophyta	Chlorophyceae	Sphaeropleales	Hydrodictyaceae	*Pediastrum duplex*
Bacillariophyta	Bacillariophyceae	Rhopalodiales	Rhopalodiaceae	*Rhopalodia*
Chlorophyta	Zygnematophyceae	Desmidiales	Desmidaceae	*Staurastrum*
Bacillariophyta	Bacillariophyceae	Fragilariales	Fragilariaceae	*Synedra*
Chlorophyta	Ulvophyceae	Ulotrichales	Ulotrichaceae	*Ulothrix*
Chlorophyta	Chlorophyceae	Chlamydomonales	Volvocaceae	*Volvox*

Table 4: List and taxonomic classification of identified phytoplankton species in Lake Tikub, Tiaong, Quezon in the month of November, 2018 (Lee 2008 taxonomic scheme)

Phylum	Class	Order	Family	Genera
Bacillariophyta	Coscinodiscophyceae	Aulacoseirales	Aulacoseiraceae	*Aulacoseira*
Pyrrophyta	Dinophyceae	Gonyaulacales	Ceratiaceae	*Ceratium*
Chlorophyta	Trebouxiophyceae	Chlorellales	Chlorellaceae	*Dictyosphaerium*
Bacillariophyta	Coscinodiscophyceae	Melosirales	Melosiraceae	*Melosira*
Cyanobacteria	Cyanophyceae	Chroococcales	Microcystaceae	*Microcystis*
Chlorophyta	Chlorophyceae	Chlamydomonales	Sphaerocystidaceae	*Sphaerocystis*
Chlorophyta	Zygnematophyceae	Desmidiales	Desmidaceae	*Staurastrum*
Bacillariophyta	Bacillariophyceae	Fragilariales	Fragilariaceae	*Synedra*

The spatial variations of the physico-chemical parameters between stations are dependent on the different land and water uses within and around the lake. The presence of a single factor, such as nutrient run-off or vegetation, affected one or more physico-chemical parameter readings. Temporal variations between these stations were likely caused by factors that are dynamic, such as changing amount of rainfall, direction of wind current, seasonal changes in atmospheric temperature and timing of anthropogenic activities such as the fish farming and feeding. The variations in amount of rainfall, wind current and atmospheric temperature may have affected the environmental factors which may then determine the phytoplankton community structure (George and Heaney 1978; Breuer et al. 2017).

Phytoplankton Community Structure

A total of 21 taxa, identified to the genus level, were observed in the euphotic zones of Lake Tikub during the sampling periods in October and November 2018 (Tables 3 and 4). The identified species belonged to four major plankton groups: diatoms, green algae, cyanobacteria and dinoflagellates. Among the 21 identified species, green algae were the richest group with 10 species, followed by diatoms (8 species) and cyanobacteria (2 species). Dinoflagellates had only one representative species. Diatoms and green algae were the most abundant phytoplankton groups in Lake Tikub.

Most identified taxa belong to the green algae, which is known as an extremely diverse group of algae especially in freshwater environments (SWCSMH 2007). The overall abundance of phytoplankton (October and November) ranged from 29 to almost 76 individuals per species. Green algae were the most abundant (51.43%); followed by the diatoms (27.62%), dinoflagellates (16.19%) and the least abundant, cyanobacteria (4.76%) (Figure 3). The eight most abundant species include *Ceratium* (16.19%), *Melosira* (13.33%), *Staurastrum* (11.43%), *Volvox* (9.52%), *Pediastrum duplex* (8.57%), *Pediastrum simplex* (7.62%), *Dictyosphaerium* (7.62%) and *Synedra* (5.71%). The composition of species varied between the sampling months, October and November (Figure 4). For example, *Volvox* was present only during the October 2018 sampling, while *Microcystis* was present only in November. Likewise, there was a decline in the population of green algae in November compared to diatoms. Photosynthetic CO_2 consumption leads to an increase in pH, and as a result, the algae may be exposed to elevated pH values during daytime. Most phototrophic microorganisms function well up to pH 9-10. Thus, even in alkaline pH values, algae were still recorded in October. Diatoms became more abundant than green algae in November since diatoms are temperature-sensitive and strongly respond to climate warming (Berthon et al. 2014). The two most abundant diatom species were *Melosira* (13.33%) and *Synedra* (5.71%). Diatoms are considered as one of the most common and dominant taxa in freshwater environments (Bellinger and Sigee 2010). In polluted water, it can exhibit tolerance towards high concentration of nutrients (Akbulut 2003; Çelekli and Külköylüoğlu 2006) thus supporting its survival. Only two species of cyanobacteria were seen, *Microcystis* and *Oscillatoria*. High nutrient levels of nitrogen and phosphorus support cyanobacterial growth (Mishra et al. 2018; Percival and

Williams 2014). Though no nutrient analysis was done, these nutrients may be low to support the cyanobacteria. *Ceratium* was the only dinoflagellate identified because dinoflagellates are naturally rare in freshwater habitats (Keshri et al. 2013). Each phytoplankton taxon has different resource requirements and responses to the physicochemical factors of the environment,

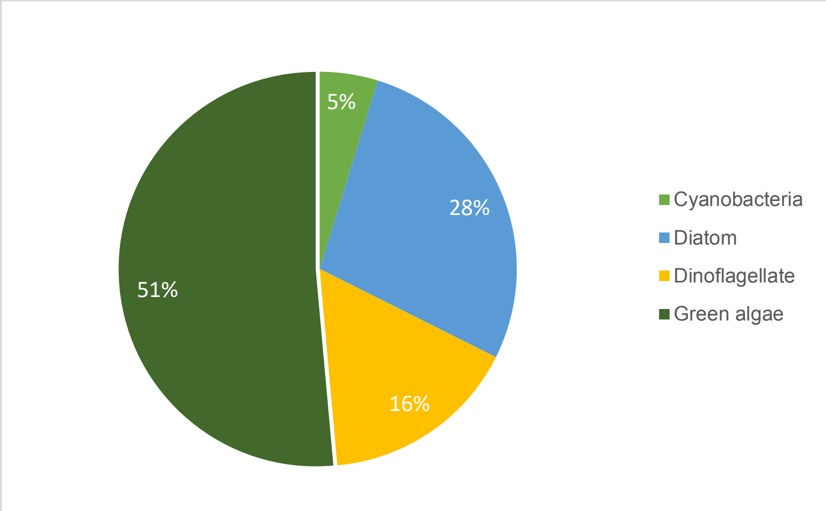

Figure 3: Relative abundance of algal species per group in Lake Tikub, Tiaong, Quezon

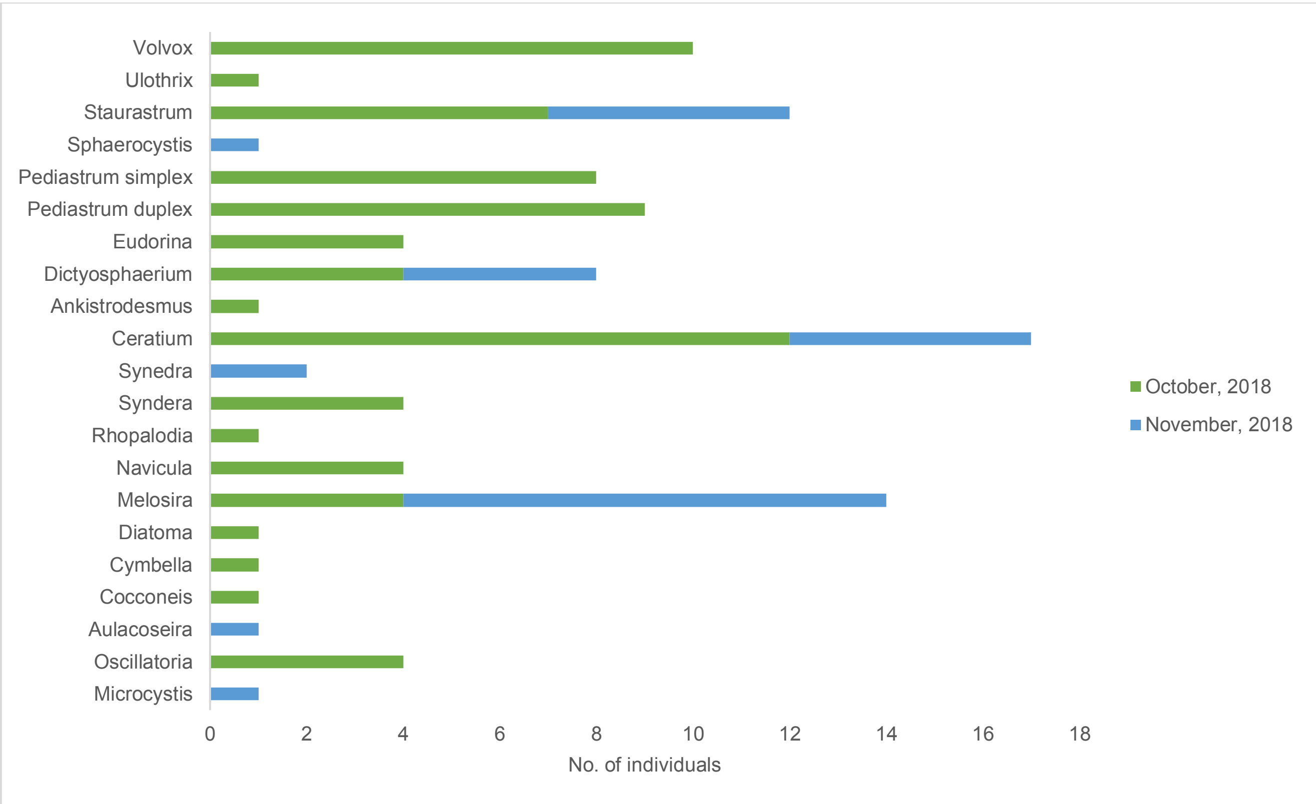

Figure 4: Phytoplankton taxa composition during October, 2018 and November, 2018 sampling at Lake Tikub, Tiaong, Quezon

thus causing variations in the composition per sampling month (Reynolds 1984).

Generally, a water body is considered clean if the diversity of diatoms is high, but the population of each species is low (Wellesley College 2010). This is congruent to the obtained results, where several species of diatoms formed small populations. Stressed environments are known to have lower number of species, with only one or two species having significantly greater individuals than the other species (Palleyi et al. 2011). In Lake Tikub, there were several abundant diatom species, namely *Melosira, Synedra* and *Navicula,* which made up 24.75% of the total cell count, indicating that the water favored the proliferation of both non- and nutrient and pollutant-tolerant species.

Phytoplankton abundance maybe affected by a number of factors, both biotic and abiotic. Aside from those measured in the study, other factors like water turbidity may play an important role particularly for diatoms such as *Melosira*, *Synedra* and *Navicula*. All of these taxa are pollution tolerant species, reaching high population as turbidity increases (Proulx et al. 1996; Maynolov et al. 2009; Bellinger and Sigee 2010). Phytoplankton abundance can be correlated with turbidity in two ways: first, turbid water has more suspended particulates including organic matter and nutrients, all of which can hasten algal growth. Second, once these phytoplankton have rapidly increased, their numerous light-trapping cells further contribute to a more turbid water. Aside from algae, the detritus and silt contents are the major particulates found in lakes contributing to high turbidity (Michaud 1991).

Dissolved oxygen did not significantly vary among sites; hence temperature and pH may have served as primary drivers of variations in phytoplankton abundance. Changes in wind current and amount of rainfall during sampling periods may also be considered as contributing factors towards the temporal variations in phytoplankton community structure. High amounts of rainfall usually observed during the month of November can cause surface run-offs which bring about nutrients into the lake thereby stimulating algal growth.

The Shannon-Weiner Index of General Diversity is a measure of species diversity in a given community. The index of general diversity of Lake Tikub was 2.434 on October and 1.659 on November. Evenness refers to how population values are close among the species in an environment; or how relative abundances are distributed among the different species (Wilsey and Stirling 2007). Lake Tikub has a dominance of 0.081 and evenness of 0.671 on October and 0.177 and 0.656 on November (Table 5).

Table 5: Diversity profile of the phytoplankton community during October, 2018 and November, 2018 at the nine sampling sites in Lake Tikub, Tiaong, Quezon

October		November	
Taxa (S)	17	Taxa (S)	8
Individuals	76	Individuals	29
Dominance (D)	0.081	Dominance (D)	0.177
Simpson (1-D)	0.919	Simpson (1-D)	0.823
Shannon Diversity (H)	2.434	Shannon Diversity (H)	1.659
Evenness (e^H/S)	0.671	Evenness (e^H/S)	0.656

Diversity and evenness have a direct relationship to each other but are indirectly related to dominance. Results show that the month of October has a lower dominance and higher evenness than in November. This may signify a possibility of algal monoculture and competition for resources in November. Lower values of dominance mean that more taxa are equally present; or there are no dominant species (Hammer et al. 2001; OECD 2001). Evenness values also revealed that the algal species are not evenly distributed. This is probably due to the fact that phytoplankton have the ability to move from one place to another as well as the temporal variations of specific abiotic factors, e.g. temperature and pH. *Ceratium* is the most abundant phytoplankton species in October. In terms of general diversity, the phytoplankton community structure shows higher algal diversity in October than November indicating fewer algal species in the area during the latter month.

Trophic State Index (TSI) based on Water Quality and Chlorophyll *a* concentration

Trophic state index (TSI) is a classification system designed to rate bodies of water based on the amount of biological activity they sustain. Under the TSI scale, in terms of water quality, Lake Tikub is oligotrophic (TSI 0-40), having the least amount of biological productivity, "good" water quality (Table 6). However, in terms of chl *a* concentration, the lake is mesoeutrophic (TSI 40-60), having a moderate level of biological activity, "fair" water quality (Table 7).

CONCLUSION AND RECOMMENDATIONS

A diverse phytoplankton community in Lake Tikub was observed. However, the occurrence of varying conditions in the lake during the sampling schedules resulted to high algal density with the dominance of *Ceratium*, a dinoflagellate during October. The almost equal abundance of these species indicated that the lake is oligotrophic and is supported by the water quality analysis results. In terms of chlorophyll a concentration, Tikub lake is classified as mesoeutrophic. The phytoplankton community may have been positively affected by the variation in the abiotic factors, specifically temperature and pH. This suggests that management strategies must address the effects of these factors especially in aquaculture. Local initiatives such as effective waste management, sustainable fishing, and proper information dissemination must be continuously implemented to prevent degradation of the lake's water quality and ultimately to prevent losses in phytoplankton composition and diversity.

Table 6: Trophic state index (TSI) values during October, 2018 and November, 2018 at the nine sampling sites in Lake Tikub, Tiaong, Quezon based on water quality analysis results

Stations	Trophic State Index based on Water Quality Analysis	
	October	November
	Trophic State Index (TSI)	Trophic State Index (TSI)
1A	40.413	39.668
1B	39.476	38.104
2A	38.716	37.787
2B	39.332	37.237
3A	37.963	38.406
3B	37.684	38.380
4A	42.051	38.156
4B	42.509	38.220
C	37.751	37.715

Table 7: Chlorophyll a concentration (μg/L) and trophic state index (TSI) during October, 2018 and November, 2018 at the nine sampling sites in Lake Tikub, Tiaong, Quezon

Stations	October		November	
	Chlorophyll *a* concentration (μg/L)	Trophic State Index (TSI)	Chlorophyll *a* concentration (μg/L)	Trophic State Index (TSI)
1A	6.796	49.400	12.264	55.190
1B	6.449	48.885	8.141	51.171
2A	6.395	48.803	27.549	63.129
2B	10.591	53.752	35.950	65.740
3A	12.725	55.553	36.959	66.012
3B	8.898	52.043	37.203	66.077
4A	9.201	52.372	37.447	66.141
4B	54.719	69.862	36.865	65.987
C	12.685	55.521	13.344	56.019

This is only an initial study on the phytoplankton diversity of Lake Tikub. More work needs to be done to address and identify the factors that determine the phytoplankton community structure of the lake. Additional physico-chemical parameters, in particular, nutrient analysis of the lake water is highly recommended.

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CONFLICT OF INTEREST

There are no conflicts of interest in this study.

CONTRIBUTIONS OF INDIVIDUAL AUTHORS

All the authors contributed to the conduct of the study and in writing the manuscript.

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