WATER QUALITY AND THIRTY-FIVE SPECIES OF BLUE-GREEN ALGAE FOUND IN TWIN TAUNG LAKE

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Abstract

The present study deals with the seasonal variation of algae and water analysis of Twin Taung Lake, Budalin Township, Monywa District, Sagaing Region. Algae and water samples were collected from October, 2018 to September, 2019. Physico-chemical parameters were analyzed in the laboratory of Department of Quality Control, June Pharmaceutical and Food Industry in Sagaing. Statistical analysis was carried out using R Studio software. Totally 35 species of Cyanophyceae were classified and recorded. Among them, *Chroococcus*, *Microcystis*, *Anabaenopsis* occurred throughout the year. Maximum values of temperature, sodium bicarbonate, total hardness and nitrate were found in summer; sodium carbonate, total alkalinity and total chloride were in rainy season and the maximum pH and phosphate occurred in winter. Highest value of salinity was in January and April. Maximum density of *Chroococcus* and *Anabaenopsis* was observed in summer. The growth of *Chroococcus* was positively correlated with salinity and negatively correlated with total alkalinity and phosphate. Growth of *Anabaenopsis* was positively correlated with pH, salinity, total hardness and nitrate. Growth of *Microcystis* was observed in winter and it was significantly correlated with season and positively correlated with pH and total hardness. It may be due to fluctuations of physico-chemical parameters of water in three seasons.

Keywords: Blue-green algae, monthly variation, physico-chemical parameters, Twin Taung Lake.

Introduction

Freshwater algae, also known as phytoplankton, are found in a large range of habitats and vary in shape and color (Anand *et al.* 2011). A great majority of them are truly aquatic and grows in ponds, lakes, puddles, etc. Besides occurring in aquatic habitats, algae are found abundantly on tree, trunks rocks and in association with other plants and animals (Gupta & Pamposh 2014). Algae are frequently occurred in polluted and unpolluted water and due to this point they are generally regarded as indicators to determine the quality of water because water is extremely important and necessary for life (Rajurkar & Dalal 2014).

Algae are playing a vital role in this world and it is the predominant primary producer in any aquatic ecosystems. It is very significant ecologically because they are involving in symbiosis with bacteria in different ecosystems. It supplies food and oxygen for many species in the aquatic environment and it's vitally crucial to maintain CO_2 of carbon cycle via photosynthesis to balance the CO_2 concentration in atmosphere (Ramaraj *et al.* 2010).

Cyanobacteria are a large and morphologically diverse group, which can survive in all kinds of water, with some species living in freshwater while others thrive in brackish water or the marine environment (Malakar & Kalita 2012). Cyanobacteria are an ancient group of prokaryotic microorganisms showing the general features of Gram-negative bacteria. They can be observed in almost all environments, including freshwater, seawater, non-acidic hot springs and deserts. Some cyanobacteria also have the ability to fix atmospheric nitrogen, yet relatively little is known about ecology of natural populations and the diversity of nitrogen-fixing cyanobacteria (Boonkerd *et al.* 2002).

The division Cyanophyta includes about 150 genera and 2000 species. They are found in the most various habitats in freshwater and in the sea, on damp soil and even in such extreme and

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inhospitable places as glaciers, deserts and hot springs. Most, however, thrive in freshwater, blue-green algae are frequently to be found in the phytoplankton of still or slowly flowing freshwaters (Hoek *et al.*1995).

Dynamics in the phytoplankton biomass are the results of the complex interaction of physical, chemical and biological processes. The availability of nutrients influences the range of the phytoplankton. From the past few decades, there is much interest to study various factors influencing the development of phytoplankton in correlation to the physico-chemical characteristics (Sharma & Tiwari 2018).

The FDA (Food Drug Administration) recognized *Spirulina* by the issuance of a GRAS (Generally Recognized as Safe) certificate in 1981. *Spirulina* is legally marketed as food or food supplement without hazard to human health. *Spirulina* is one of the most studied microalgae around the world, due to its high nutritional value and the presence of active biomolecules. *Spirulina* inhabit in natural environment characterized by brackish, alkaline and natroned waters (high concentrated in carbonates and bicarbonates) of the intertropical zone. It grows in warm conditions (28 – 40 ºC), with a high light intensity (Vernès *et al.* 2019). In Myanmar, natural *Spirulina* is produced from the natural lakes of Twin Taung, Twin Ma, Taung Pyauk and Yae Kharr in Sagaing Region. Twin Taung Lake is located in Budalin Township, Twin Ma and Taung Pyauk Lakes are located in Kani Township and Yae Kharr is located in Sagaing Township. After 2014, the blooming of natural *Spirulina* is disappeared at all in Twin Taung Lake. After falling commercial production of *Spirulina* from Twin Taung Lake, there was not any research to know the diversity of algae growing in Twin Taung Lake by previous workers in Myanmar.

Therefore, it was interested to study on algal flora of Twin Taung Lake. The aims of this study were to know which algae occur in which month of a year, to determine which algae grow all the year round and to access the physico-chemical parameters of water in Twin Taung Lake. The objectives of this study were to study the seasonal variation of algae and to evaluate the water quality of Twin Taung Lake.

Materials and Methods

1. Study Area

Twin Taung Lake is situated at Monywa District in Sagaing Region. It is about 9.66 km from east west of Budalin Township. The surface area of lake is 89.4 hactares; 1040 m from east to west, 1150 m from north to south and the depth of lake is about 51.21 m at the deepest place. It is situated between North Latitudes 22° 20' 56.38" and 22° 22' 44.22", between East longitude 95° 0' 24.28" and 95° 2' 12.66", 82 m of elevation as shown in Figure 1.

2. Sampling Sites

Eleven sampling sites were chosen as shown in Figure 2. Among these, the fresh water from Chindwin River is leaking into the lake at Moemalal (site 10) and Yaenatgyi (site 11).

3. Collection and Classification of the Algal Specimens

Algae specimens were collected monthly during October 2018 to September 2019, by using plankton net. The collected specimens were identified up to specific level based on their morphological characters by referring on Desikachary (1959), Prescott (1962), Komárek & Anagnostidis (2005), John *et al*. (2011) and Komárek (2013).

4. Counting the Number of the Cells and Relative Abundance Percent of Algae

The number of algae belonging to different genera were determined and counted under the microscope using a haemacytometer and are calculated with the following formula used by Lavens and Sorgeloos (1996) and then calculated by relative abundance (%).

Number of cell mL^{-1} = $(n_1 + n_2) / (2 + 80) + 80 + 10^3 + d$

= $(n_1 + n_2) / 2 + 10^3 + d$

n_1 = number of cells counted in upper rafter

n_2 = number of cells counted in lower rafter

d = dilution factor

For greater accuracy make 3 duplicate counts

The relative abundance (%) of a particular algae type was calculated by employing the following formula:

$$\text{Relative abundance (\%)} = \frac{Y}{X} \times 100$$

Where,

X = total number of samples collected

Y = number of samples from which a particular algae type was isolated

5. Collection of Water Samples and Analysis of Water Quality

Water samples of all sampling sites were collected monthly from the different layers-: surface, 1.52 m and 3.05 m intervals of the water column by using water sampler. Physico-chemical parameters (i.e. salinity, hardness, alkalinity, sodium carbonate, sodium bicarbonate, chloride, nitrate and phosphate) of water samples were analysed at laboratory of Department of Quality Control, June Pharmaceutical and Food Industry of Sagaing. Temperature and pH of water were measured by thermometer and pH meter in the field.

6. Statistical analysis

Multiple regressive analyses were performed to determine the relationship of algae with physico-chemical parameters. Statistical analysis was carried out using R Studio software.

Figure 1 Location Map of Budalin Township, Monywa District, Saging Region

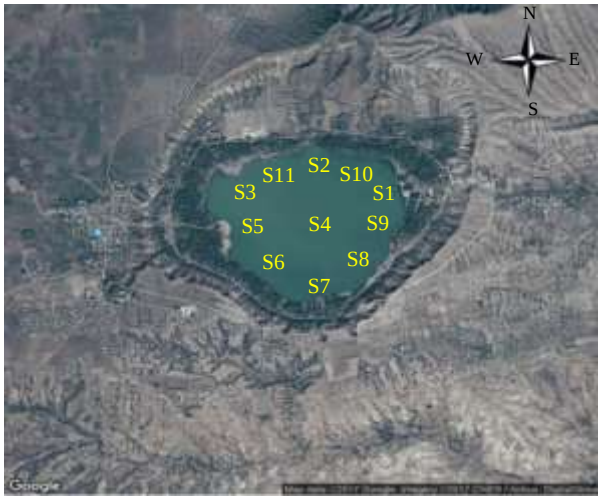

Figure 2 Map showing the collection sites

S1 (sampling site 1) = North-east part of lake, S2 = North part of lake,
S3 = North-west part of lake, S4 = Middle part of lake, S5 = West part of lake, S6 = South-west part of lake, S7 = South part of lake, S8 = South-east part of lake, S9 = East part of lake, S10 = Moemalal and S11 = Yaenatgyi.

Results

Totally 35 species belonging to 11 genera, 9 families and 5 orders of the class Cyanophyceae was classified, described, and recorded. The list of algae species was as shown in Table 1.

1. Monthly variation of algae in all sampling sites

Although microalgae belonging to class Cyanophyceae occurred throughout the year the species of *Chroococcus, Microcystis* and *Anabaenopsis* were observed monthly (Figure 3). The highest growth of *Chroococcus* was in April and the lowest in December. The highest growth of *Microcystis* was found in November and lowest in August. The maximum growth of *Anabaenopsis* occurred in early summer month of February and lowest in April.

According to statistical analysis, the growth of *Chroococcus* was positively correlated with salinity and negatively correlated with total alkalinity and phosphate (Table 2). The growth of *Microcystis* was observed in winter and positively correlated with pH and total hardness (Table 3). The growth of *Anabaenopsis* was positively correlated with pH, salinity, total hardness and nitrate (Table 4).

Table1 List of 35 species of blue-green algae observed in Twin Taung Lake

No.	Species Names	No.	Species Names
1.	*Aphanocapsa grevillei* (Berkeley) Rabenhorst	20.	*Phormidium chalybeum* (Merterns ex Gomont) Anagnostidis & Komarek
2.	*A. rivularis* (Carmichael) Rabenhorst	21.	*P. tenue* Gomont
3.	*Chroococcus globosus* (Elenkin) Hindak	22.	*Arthrospira argentina* (Frenguelli) Guarrera & Kuhvemann
4.	*C. minimus* (Keissler) Lemmermann	23.	*A. massartii* Kuffareth
5.	*C. tenax* (Kirchner) Hieronymus	24.	*A. platensis* Gomont
6.	*C. turgidus* (Kutzing) Nageli	25.	*Spirulina laxissima* forma *major* Desikachary
7.	*C. turgidus* var. *maximus* Nygaard	26.	*S. maior* Kutzing ex Gomont
8.	*Merismopedia minima* G. Beck	27.	*S. subsalsa* Oersted ex Gomont
9.	*M. punctata* Meyen	28.	*Borzia periklei* Anagnostidis in Anagnostidis & Komarek
10.	*Microcystis aeruginosa* (Kutzing) Kutzing	29.	*Anabaena minispora* M. Watanabe
11.	*M. flos-aquae* (Wittrock) Kirchner	30.	*Anabaenopsis arnoldii* Aptekar
12.	*M. marginata* (Meneghini) Kutzing	31.	*A. arnoldii* var. *indica* Ramanathan
13.	*M. protocystis* W. B.Crow	32.	*A. circularis* var. *javanica* Woloszynska
14.	*M. viridis* (A. Braun) Lemmermann	33.	*A. magna* Evans
15.	*Oscillatoria acuminate* Gomont	34.	*A. milleri* Woronichin
16.	*O. acuta* Bruhl *et* Biswas, Geitler	35.	*A. tanganyikae* (G. S. West) Woloszynska & V. V. Miller
17.	*O. euboeica* Anagnostidis		
18.	*O. meslinii* Fremy		
19.	*O. princeps* Vancher ex Gomont		

2. Physico-chemical parameters of water samples in all sampling sites

The result on the variation of physico-chemical parameters at monthly intervals as shown in Figure 4 – 8. The range of temperature was observed from 28.4 ºC to 35.2 ºC. The highest was in April and the lowest in December. The value of pH ranged from 9.6 to 9.9 and the highest value was in December and the lowest in March, April, July, August and September. The highest salinity value was 4‰ and it was in January and April (late winter and summer). The value of sodium carbonate (Na_2CO_3) was ranging from 878 – 1143 mg/L, the maximum value was June and the minimum value was in October. The value of sodium bicarbonate ($NaHCO_3$) was ranging from 1600 – 1932 mg/L, the maximum value was April and the minimum value was in December. The highest value of total alkalinity was 2984 mg/L in June and the lowest value 2614 mg/L was in December. The value of total chloride was highest in September and it was 302 mg/L and the lowest value 135 mg/L in October was gradually increased up to May with the value of 194 mg/L. The peak result of total hardness was 275 mg/L in February and the lowest one was 226 mg/L in January. The highest nitrate level was detectable in March 33.6 mg/L and revealed a wide variation and the lowest value was 11.1 mg/L in November. The highest phosphate level was measured in December and it was 1.57 mg/L and did not show much variation in other months during the study period.

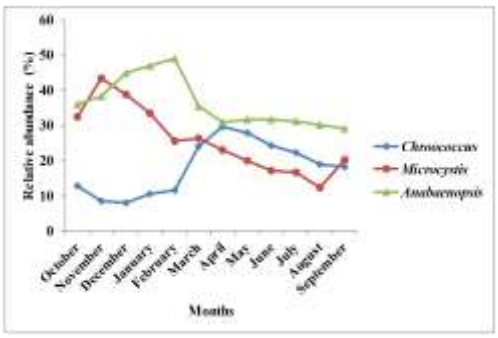

Figure 3 Monthly variation of the population of genus *Chroococcus*, *Microcystis* and *Anabaenopsis* as in one unit

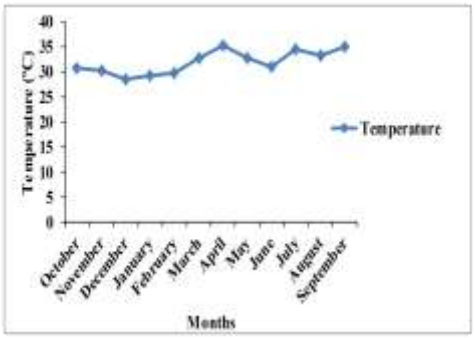

Figure 4 Monthly variation temperature (ºC) of water in Twin Taung Lake

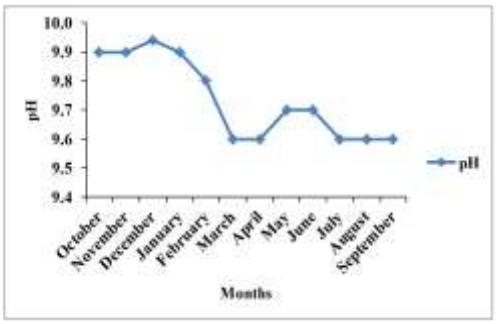

Figure 5 Monthly variation pH of water in Twin Taung Lake

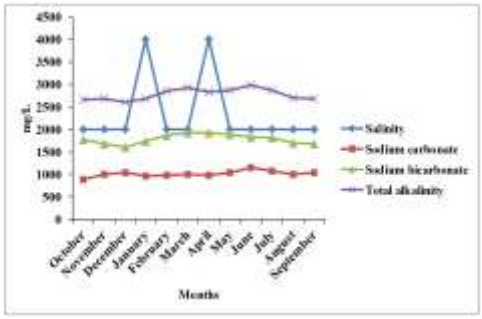

Figure 6 Monthly variation of salinity, sodium carbonate, sodium bicarbonate and total alkalinity of water in Twin Taung Lake

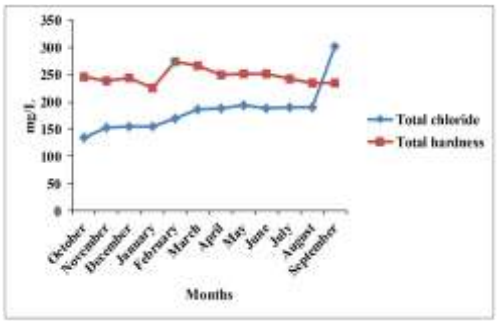

Figure 7 Monthly variation of total chloride and total hardness of water in Twin Taung Lake

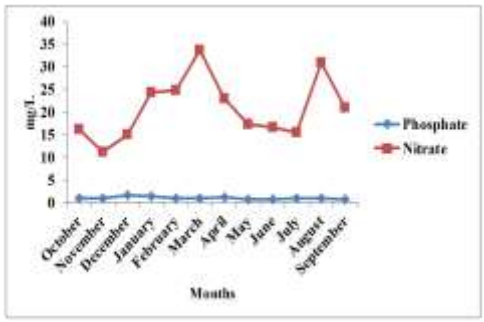

Figure 8 Monthly variation of phosphate and nitrate of water in Twin Taung Lake

Table 3 Regression analysis result of genus *Chroococcus* and environmental variables

Coefficient:	Estimate	Std. Error	t value
(Intercept)	47.16295	36.43983	1.294
Temperature	-0.01724	0.04683	-0.368
pH	-4.93420	3.68214	-1.34
Salinity	0.67014	0.33659	1.991*
Na_2CO_3	0.00334	0.00333	1.003
$NaHCO_3$	0.00311	0.00294	1.058
Alkalinity	-0.00416	0.00195	-2.13*
Chloride	-0.00563	0.00633	-0.889
Hardness	0.03954	0.02727	1.450
NO_3	-0.00925	0.02082	-0.444
PO_4	-1.13773	0.35014	-3.249**
factor (Season) Summer	0.39643	0.70456	0.563
factor (Season) Winter	-0.23136	1.3045	-0.177

*Significance at 0.05 level
**Significance at 0.01 level

Table 4 Regression analysis result of genus *Microcystis* and environmental variables

Coefficient:	Estimate	Std. Error	t value
(Intercept)	-1.22E+02	4.71E+01	-2.584*
Temperature	8.47E-02	6.05E-02	1.399
pH	9.91E+00	4.76E+00	2.083*
Salinity	1.22E-01	4.35E-01	0.28
Na_2CO_3	3.09E-03	4.30E-03	0.719
$NaHCO_3$	2.16E-03	3.80E-03	0.569
Alkalinity	-2.50E-04	2.52E-03	-0.099
Chloride	6.99E-03	8.18E-03	0.854
Hardness	7.62E-02	3.52E-02	2.163 *
NO_3	1.42E-02	2.69E-02	0.529
PO_4	-2.09E-01	4.52E-01	-0.461
factor (Season) Summer	2.13E+00	9.10E-01	2.336*
factor (Season) Winter	7.22E+00	1.69E+00	4.283***

*Significance at 0.05 level
***Significance at 0.001 level

Table 5 Regression analysis result of genus *Anabaenopsis* and environmental variables

Coefficient:	Estimate	Std. Error	t value
(Intercept)	-3.75E+02	5.76E+01	-6.499 ***
Temperature	1.12E-01	7.41E-02	1.517
pH	3.61E+01	5.82E+00	6.201 ***
Salinity	1.47E+00	5.32E-01	2.757 **
Na_2CO_3	-3.52E-03	5.26E-03	-0.669
$NaHCO_3$	-5.00E-03	4.65E-03	-1.075
Alkalinity	6.41E-04	3.09E-03	0.208
Chloride	4.03E-03	1.00E-02	0.403
Hardness	1.38E-01	4.31E-02	3.196 **
NO_3	1.10E-01	3.29E-02	3.327 **
PO_4	-3.50E-02	5.54E-01	-0.063
factor (Season) Summer	2.77E-01	1.11E+00	0.248
factor (Season) Winter	-2.18E+00	2.06E+00	-1.057

**Significance at 0.01 level
***Significance at 0.001 level

Discussion and Conclusion

Totally 35 species of Cyanophyceae collected from Twin Taung Lake during 2018 – 2019 were recorded in the present study. In lake Twin Taung, the maximum population of Cyanophyceae occurred in winter and early summer season and the minimum population was found in rainy season. This finding agreed with Agale *et al.* (2013).

During the study period, the relative abundance (%) of 3 genera-: *Chroococcus, Microcystis* and *Anabaenopsis* of Cyanophyceae were more dominant than the others and they were observed throughout the year. Among them, *Anabaenopsis* was observed as the highest relative abundance (%) and followed by *Microcystis* and *Chroococcus*.

In the present study, the highest growth of *Chroococcus* was observed in April (summer) and the lowest was observed in December (winter). In April, the highest value of temperature and sodium bicarbonate occurred and the lowest value was observed in December. Similar observation was in agreements with Sharma & Tiwari (2018).

The highest growth of *Microcystis* was observed in November (winter) and the lowest content of nitrate was observed in this month. The high growth of this genus occurred in high pH (9.9) of lake water this area. This finding agreed with Imai *et al*. (2009).

During the study period, the maximum value of *Anabaenopsis* occurred in early summer month of February and the highest content of total hardness was observed in this month. In late summer the growth of this genus was decreased up to September. This observation was agreed with Aguilera *et al.* (2016).

During October 2018 to September 2019, the lowest temperature was 28.4 ºC in December and the highest was in April (35.2ºC). pH of lake water was observed in the range of 9.6 to 9.9 indicating alkalinity throughout the period of this study. Generally, high level of pH of water promotes the growth of algae. In the present study, higher values of pH were recorded in winter and lower during rainy season. This finding agreed with Suresh (2013) who stated that the higher values of pH were recorded in winter and lower during the monsoon.

The highest value of salinity was 4‰ in January (late winter) and April (summer), 2‰ in other months and not constant. These findings were similar to Singh (2015). The value of sodium carbonate (Na_2CO_3) was ranging from 878 – 1143 mg/L, the maximum value was in June and the minimum was in October. The value of sodium bicarbonate ($NaHCO_3$) was ranging from 1600 – 1932 mg/L, the maximum value was in April and the minimum was in December. These observations were similar to Sahni & Yadav (2012).

Total alkalinity value was between 2614 mg/L and 2984 mg/L. The highest concentration of total alkalinity was recorded in rainy and summer. Low concentration of total alkalinity was recorded in winter. This finding agreed with Dorche *et al.* (2018) and Jyotsna *et al*. (2014). The value of chloride was 302 mg/L highest in September, the lowest was 135 mg/L in October and it was gradually increased up to September. The growth of algae observed throughout of the year was not in high growth in September. Perrotte (2008) stated that the chloride salts, when used cause the decrease in population of thousands of organisms, especially algae.

The highest value of total hardness was observed in early summer (February) and the lowest was in late winter. This finding agreed with Sahni & Yadav (2012) and Agale *et al.* (2013). The highest nitrate level (33.6 mg/L) was detectable in March and the lowest one was 11.1 mg/L in November revealed a wide variation. The highest phosphate level was measured in December and it was 1.57 mg/L and did not show much variation in other months during the study period. These findings agreed with Sahni & Yadav (2012).

It may be concluded that as in the seasonal variation, maximum algal density of *Chroococcus* and *Anabaenopsis* was recorded in summer due to high temperature and rich in nutrients in water and high the rate of photosynthesis in summer months. The low density of phytoplankton in rainy may be due to heavy flood water inflow and they were resumed again due to dilution. And then this may be due to the fluctuation of physico-chemical parameters of the water body in Lake Twin Taung.

According to statistical analysis, the growth of *Chroococcus* was positively correlated with salinity and negatively correlated with total alkalinity and phosphate. The growth of *Microcystis* was observed in winter and it was significantly correlated with the season and positively correlated with pH and total hardness. The growth of *Anabaenopsis* was positively correlated with pH, salinity, total hardness and nitrate.

This research is beneficial for country. After 2014, the production rate of natural *Spirulina* was decreased and incomes of national government fall down due to disappearance of beneficial algae, therefore it will be done for further study from the phycological and liminological point of view.

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