Population And Diversity Of Phytoplankton On Ramadan In Situ Gintung Lake, South Tangerang, Banten Province, Indonesia

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A b s t r a c t

Changes in the social behavior of Moslems before, during and after Ramadan may impact on lake ecosystems. The aim of this study was to investigate temporal variation in the phytoplankton community of Situ Gintung lake, South Tangerang, Banten Province before, during and after of Ramadan periods 2015. Community composition, abundance, diversity (Shannon-Wiener index H'), dominance (D) and evenness (J) were measured for phytoplankton assemblages. Phytoplankton belonging to 7 divisions and 64 species were found. Phytoplankton belonging to 7 divisions and 64 species were found. The abundance, diversity and evenness indices of phytoplankton showed no significant temporal variation except dominance index.

1. Introduction

Lake ecosystems have been used as waste disposal sites, commonly receiving domestic and factory sewage (Chen et al., 2016). Increased social activities community around the lake can lead to eutrophication, contamination of water, species invasion, genetic changes (Brönmark & Hansson, 2002), algae blooms (Duan et al., 2009), public health issue (Zhang et al., 2009) and Coliform total (Wardhana et al., 2017). One of the changes in social activities occurs in the before, during and after Ramadan periods.

The month of Ramadan is fasting time for the Moslem population with its specific requirement that is they be intelligent and mature (Al-Qurthubi, 1995). The condition before, during and after of Ramadan periods was changing the society behavior in the Moslem majority country such as Egypt (Afifi, 1997), Indonesia and Malaysia (Ra, 2016). Social behavior, consumption (Kadri et al., 2000) and economic activities in general change (Ra, 2016) with trash increasing during Ramadan (Wardiha et al., 2014), which may in turn negatively affect freshwater (Wardhana et al., 2017).

Diversity index and community structure have been used as an indicator to measure of pollution level in the lake ecosystem. Diversity index is being used for ecologists to measure diversity in aquatic ecosystems (Washington, 1984). Diversity of phytoplankton are used to measure the pollution level of waters lake which is affected by water temperature (Shanthala et al., 2009), oxygen, nitrogen, phosphorus (Napiórkowska-Krzebietke, 2009), brightness, depth, wind speed, solar radiation, precipitation (da Costa & Dantas 2011), eutrophication (Carvalho et al., 2013) in the lake ecosystem. The long-term study on the lake ecosystem (Borics et al., 2014) and phytoplankton diversity index can be used for assessment of water quality (Carvalho et al., 2013).

The diversity of phytoplankton in the lake ecosystem has been reported of the previous studies (Napiórkowska-Krzebietke, 2009; Shanthala et al., 2009; da Costa & Dantas 2011; Carvalho et al., 2013; Borics et al., 2014), including of Situ Gintung lake (Kristiana, 2003). However, phytoplankton assemblages in Situ Gintung lake before, during and after Ramadan periods have not been reported. Therefore, the present study aimed to investigate temporal variation in the phytoplankton community

2. MATERIALS AND METHODS

Study area

The study was conducted in Situ Gintung lake, South Tangerang city, Banten Province, Indonesia (Figure 1). Samples were taken before (May-Jun), during (Jun-Jul) and after (Jul-August) Ramadan periods 2015, all within the dry season with a monthly average air temperature of 30-34 ℃ and precipitation 0-87 mm (**http://www.accuweather.com**).

Sampling procedures

The sampling of phytoplankton and measurement of chemical and physical variables were conducted on the surface water (0 meter) at 5 stations (stations 1 and 5: inlet, station 3: outlet, station 2: near the village, station 4: near the farm). The sampling and measurement of variables were conducted on 3 weekly occasions (W1, W2 and W3) in every month on before, during and after Ramadan periods.

Samples of phytoplankton were collected through a filtration method (Bellinger and Sigee, 2015): 16 liters of lake water were filtered through a plankton net (mesh size, 50 µm) to obtain 20 ml, to which drops of Lugol's iodine (10%) were added. Phytoplankton were identified according to Prescott (1954), Karacaoglu et al. (2004), van Vuren et al. (2005) and Bellinger and Sigee (2015).

Data analysis

Phytoplankton composition, abundance, diversity (Shannon-Wiener index, H'), dominance (D) and evenness (J') were measured, following Brower *et al.* (1990). ANOVA (Duncan test) was used to test the differences in population/community measures before, during and after Ramadan (SPSS IBM version 21).

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3. RESULTS

Population of Phytoplankton

A total of 64 species belonging to 7 divisions were recorded in the present study (Table 1). The highest number of species (28) were Chlorophyta, followed by Bacillariophyta (15), Cyanophyta (12), Euglenophyta (5), Cryptophyta (3), Chrysophyta (1) and Dinophyta (1).The result of SDS-PAGE analysis revealed that the protein bands with TCA precipitation were more appeared than without precipitation (Figure 1). The profile of variety Dering-1 protein also indicated that there were 10 bands with TCA precipitation and only 7 bands without precipitation. However, on the protein without precipitation indicates the induced a new protein in drought stress conditions.

The number of divisions and of individuals of phytoplankton in Situ Gintung before, during and after the Ramadan are shown in Figure 2 and 3. These did not show significant temporal variation (ANOVA, p > 0.05). Phytoplankton of Situ Gintung had value of 4 and 6, 4 and 5, and 5 and 6 divisions in before, during and after the Ramadan, respectively (Fig. 2; ANOVA, p > 0.296). Divisions of Cyanophyta, Chlorophyta, and Bacillariophyta are dominant in the before, during and after Ramadan periods (Fig. 3; ANOVA, p > 0.942).

The period of before Ramadan, the following numbers were recorded: Cyanophyta 37.436, Chlorophyta 10.969, Euglenophyta 1.530, Cryptophyta 1275, Bacillariophyta 2.806, Chrysophyta 446 and Dinophyta 382 individuals/liter. During Ramadan, the total numbers were: Cyanophyta 42.729, Chlorophyta 17.793, Bacillariophyta 1.977, Cryptophyta 574, Euglenophyta 446 individuals/liter, while no Chrysophyta and Dinophyta were found. After Ramadan, the numbers were: Cyanophyta 42.410, Chlorophyta 11.734, Bacillariophyta 2.614, Chrysophyta 382, Euglenophyta 318,

Cryptophyta and Dinophyta 63 individuals/liter (Fig. 3a-c). The average of individuals in all periods were the lowest value of 14413 ind/L and the highest of 28380 ind/L (Fig. 3d).

Phytoplankton Indices

The relative abundances of phytoplankton of Situ Gintung are shown in Figure 4. Richness, diversity, and evenness of phytoplankton on those periods were similar. Before Ramadan, the richness and diversity of phytoplankton at station 2 were higher than at stations 3, 4, 1 and 5, while dominance was the opposite and evenness at station 5 was more pronounced than at stations 1, 4, 3 and 2, respectively (Figure 4a). Phytoplankton richness and diversity during Ramadan were higher at station 4 than at station 2, 3, 1 and 5, whereas dominance was the inverse and evenness was greater at station 3 than at 2, 5, 1 and 4 (Figure 4b). After Ramadan, the phytoplankton community was different between richness, diversity and evenness at station 5 is higher than stations 3, 1, 2 and 4 (Figure 4c).

Diversity, dominance, and evenness of phytoplankton in Situ Gintung are shown in Table 2. The diversity index was not significantly different across months and stations (ANOVA, p > 0.948). Before and after of Ramadan, the highest diversity value of 1.24 occurred at station 5 and the lowest (0.89) at station 2 during Ramadan. There was not significant different (ANOVA, p > 0.740) variation in dominance index of those periods, where after Ramadan the highest value of 0.26 and the lowest value of 0.8 those periods. The evenness index of those periods there is no significant different (ANOVA, p > 0.841) where the highest index value of 0.86 and the lowest of 0.67 on during Ramadan.

4. Discussion

The total of phytoplankton population and divisions was different from the previous study conductedin March until May 2002 in Situ Gintung which found only 2 divisions i.e.

Cyanophyta and Chlorophyta (Kristiana, 2003) while the present study found 7 divisions. The results suggested that the lake condition has secondary succession, which caused by dam damage in 2009 or disturbances such as changes in temperature cause the number of phytoplankton populations increase. Climate change, water temperature, limit of light, high salinity and nutrient as a factor succession of phytoplankton in the lake. Furthermore, the disturbed lake ecosystem has the species richness lower than compared to undisturbed (Padisak, 1993).

Chlorophyta, Bacillariophyta, and Cyanophyta divisions dominated in those periods. The results of previous studies showed Chlorophyta, Bacillariophyta and Cyanophyta found in rainy, dry (Lung'ayia et al., 2000), spring, fall (Tian et al., 2013), summer, nutrient enrichment, (Çelik & Ongun, 2007), high of pH (López-Archilla et al., 2004) and all months (Thakur et al., 2013). Furthermore, the existence of Cyanophyta and Chlorophyta influenced by high pH, nitrite, and phosphorus (Sulastri, 2011). In addition, the divisions of Bacillariophyta and Cyanophyta in the tropical lake also influenced by waters depth (Sabo et al., 2008).

Chlorophyta was showed by a large number of species, where the 14 of species absent and present in those periods (Table 1). The species of *Actinastrum* sp., *Chlorella* sp., *Monoraphidium* sp., *Pandorina morum*, *Selenastrum* sp. and *Sphaerocystis* sp. were dominated in those periods. The results of previous studies showed the *Actinastrum* sp., *Chlorella* sp., *Selenastrum* sp. and *Sphaerocystis* sp. found all months, low and high of water transparency, temperature, TN, TP and DO (Tian *et al.*, 2013). *Monoraphidium* sp. abundant in the eutrophic lakes (Bellinger & Sigee, 2015) and *Pandorinamorum* were found in summer, autumn (Çelekli *et al.*, 2007) and spring (Sevindik, 2010). Chlorophyta found in the dry season, correlated with the transparency (Çelik & Ongun, 2007), pH, high of nitrite (Sulastri, 2011) and increase the temperature to 39 °C

(Shanthala *et al.*, 2009). The previous study showed that the temperature is an important variable for the Chlorophyta (Kagalou *et al.*, 2003).

Bacillariophyta found the 5 of species, where 10 of species were not found in those periods. The species of *Actinocyclus* sp., *Coconeispedicula*, *Diatoma* sp., *Diploneis* sp. and *Nitzschia acicularis* were dominated in those periods (Table 1). The results of previous studies showed *Coconeis pedicula* and *Diatoma* sp. were found in summer (Thakur *et al.*, 2013) and *Actinocyclus* sp., *Diploneis* sp. and *Nitzschia acicularis* were found in winter (Sevindik, 2010), water temperature (Tian *et al.*, 2013), pH and BOD$_5$ (Thakur *et al.*, 2013) low and high value. Bacillariophyta influenced by transparency (Wu *et al.*, 2013), temperature, COD, BOD$_5$, N/P, total nitrogen and pH (Tian *et al.*, 2013). Bacillariophyta found predominantly in the spring, winter (Çelik& Ongun, 2007), summer (Thakur *et al.*, 2013), correlation with transparency (Wu *et al.*, 2013) and temperature increase at 32 °C (Merina *et al.*, 2014) to 39 °C (Shanthala *et al.*, 2009).

We found the 8 species belong to Cyanophyta division were *Anabaena* sp., *Chroococcus* sp., *Cylindrospermopsis* sp., *Gloeocapsa* sp., *Merismopedia punctata*, *Oscillatoria brevis*, *O. pronceps* and *O. rubescens* (Table 1). The Anabaena sp. and Merismopedia punctate increase in summer (Sevindik, 2010), *Cylindrospermopsis* sp. tolerance with light and nitrogen (Reynolds, 2006), *Chroococcus* sp. found in summer and winter (Tian *et al.*, 2013), *Oscillatoria brevis*, *O. pronceps* and *O. rubescens* found in winter and summer (Thakur *et al.*, 2013). Cyanophyta has a strong response to the increase of pH (López-Archilla *et al.*, 2004) and temperature (Schabhüttl*et al.*, 2013). It is a cause of dominant in the lake ecosystem (López-Archilla *et al.*, 2004; Çelik & Ongun, 2007).

The species of *Euglena* sp. and *Phacus* sp. dominance in those periods (Table 1). The results of previous studies showed those species can be found in water temperature high (Çelik & Ongun, 2007) summer, winter (Thakur *et al.*, 2013), water transparency, temperature, TN, TP and DO low and high (Tian *et al.*, 2013). Euglenophyta influenced by the end of the dry season (Sulastri, 2011), summer, autumn (Sevindik, 2010), winter and spring (Wu *et al.*, 2013), nutrient enrichment (Çelik & Ongun, 2007), increase the temperature to 39 °C (Shanthala *et al.*, 2009). Furthermore, the high of nitrate and low of DO correlation with the existence of Euglenophyta (Sulastri, 2011).

Cryptophyta species found in those periods were *Cryptomonas* sp. and *Haematococcus* sp. (Table 1). The previous studies showed *Cryptomonas* sp. was found every month (Shanthala *et al.*, 2009), winter (Sevindik, 2010) and summer (Thakur *et al.*, 2013). *Haematococcus* sp. found small water bodies (Bellinger & Sigee, 2015) and this study we found water temperature was high. The division of Cryptophyta found in the summer, winter, spring, autumn, and correlation with transparency (Wu *et al.*, 2013), associated with phosphorus, nitrogen, nitrate total (Fisher *et al.*, 2013), and the average depth of less than 1 m (Wu *et al.*, 2013).

Chrysophyta and Dinophyta found 1 species in those periods were *Synura* sp. dan *Peridinium* sp. (Tabel 1). Chrysophyta has been reported was found in the dry season and abundant at the beginning of the rainy season (Sulastri, 2011), winter (Thakur *et al.*, 2013) and spring (Wu *et al.*, 2013), correlation with environmental variables of TN, ammonia, conductivity, temperature, high turbidity (Sulastri, 2011), phosphorus and nitrate total (Fisher *et al.*, 2013). The studies showed *Synura* sp. was influenced by water stratification, lake depth, NO_3-N (Tolotti *et al.*, 2003) and correlation with TN, TP, and nutrient (Fisher *et al.*, 2013). Division of Dinophyta was correlated with phosphorus, nitrogen and nitrate total (Fisher *et al.*, 2013). The species of *Peridinium*

sp. were influenced by water temperature, COD (Grigorszky *et al.*, 2003), water and temperature stratification, alkalinity, altitude of lakes (Tolotti *et al.*, 2003), seasons and water level of lake (Shams *et al.*, 2012).

The richness, diversity, evenness, and dominance indices of phytoplankton were influenced by chemical and physical variables. Phytoplankton dominance was found in Situ Gintung is Cyanophyta (Figure 2) were suggested to be influenced by chemical and physical variables. Results of previous studies showed the high of pH causes the abundance of Cyanophyta (order Chroococcales and Nostocales) become dominant and low diversity (López-Archilla *et al.*, 2004). Furthermore, the abundance of phytoplankton was influenced by the high nutrient inputs from human activities around the lake (Çelik & Ongun, 2007) and seasons (Shams *et al.*, 2012; Tian *et al.*, 2013; Mohebbi *et al.*, 2016).

Diversity phytoplankton in Situ Gintung was ranged from low to high. The previous studies showed in the Nansi lake with the value of diversity phytoplankton are 3.29 to 5.21 and the value of evenness are 0.68 to 0.90 (Çelik & Ongun, 2007). In addition, in the Shimoga lake, India with the value of range diversity from 1.4 to 1.7 and dominant value of 0.95 to 0.98 (Shanthala et al., 2009). Diversity phytoplankton of low were influenced by pH (López-Archilla et al., 2004), high of pollution (Shanthala et al., 2009), water temperature (Çelik & Ongun, 2007; Schabhüttl et al., 2013) and seasons (Shams et al., 2012), whereas high diversity were influenced by high of total nitrogen and phosphorus (Çelik & Ongun, 2007).

The dominance value of phytoplankton in Situ Gintung close to 1, this categorized as low value. Evenness value of phytoplankton close to 1 in all stations and before, during and after Ramadan periods, it is indicated that the phytoplankton were evenness. The value of dominance and evenness of species close to 1 were a good category (Brower et al., 1990). The dominance of phytoplankton influenced

by season (Çelik & Ongun, 2007) and high of pollution (Shanthala et al., 2009). Phytoplankton species predominate in aquatic ecosystems effect the distribution uneven (Motwani et al., 2014). Diversity index of phytoplankton can elucidate the condition of lake ecosystem, the value of 0 to 0.5 indicates a low diversity and the value of 0.5 to 1 is high (Shanthala et al., 2009).

Proteins on the molecular weight 24,6 kDa were expected induced by the genes responsive to drought stress conditions. Shinozaki and Shinozaki (1997), the expression of certain genes is influenced by a number of reaction of a number of genes that can be active (on) or inactive (off) because the time and the environment.

5. Conclusion

Phytoplankton community on before, during and after Ramadan periods of Situ Gintung lake were shown not significant differences. Our result indicates that the changes of activity and human behavior on those periods did not influence the phytoplankton community. But, the previous studies showed, before, during and after Ramadan periods have been influenced by social activity (Wardhana et al., 2017).

6. Acknowledgements

7. References

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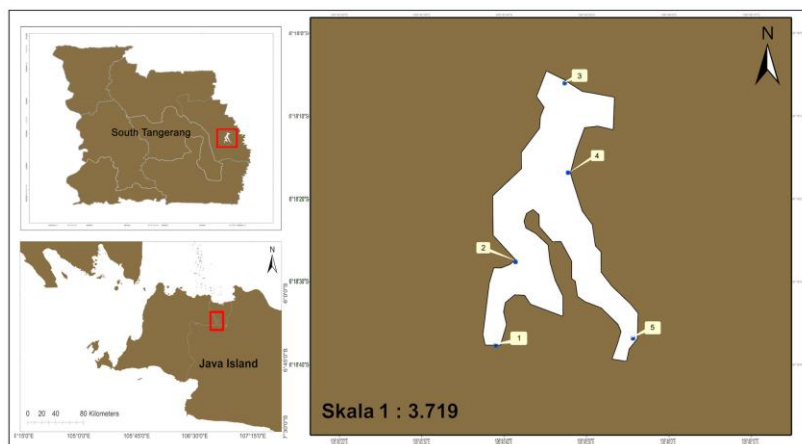
Figure 1. Map showing the research site of Situ Gintung lake (Wardhana *et al.*, 2017)
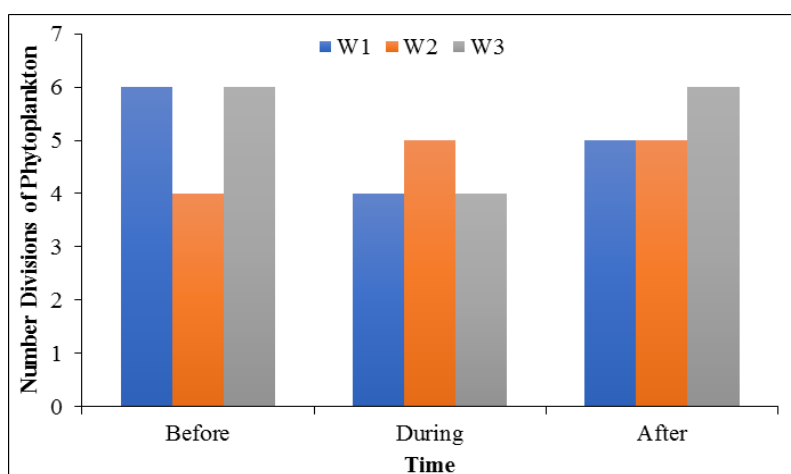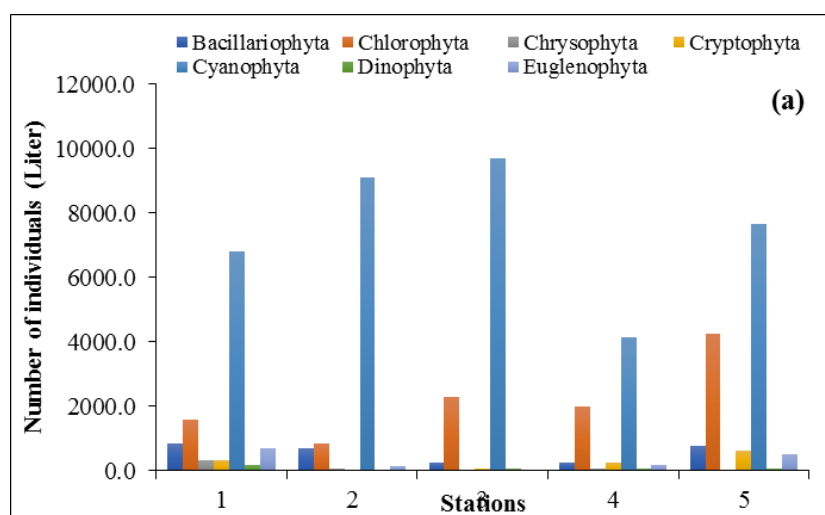

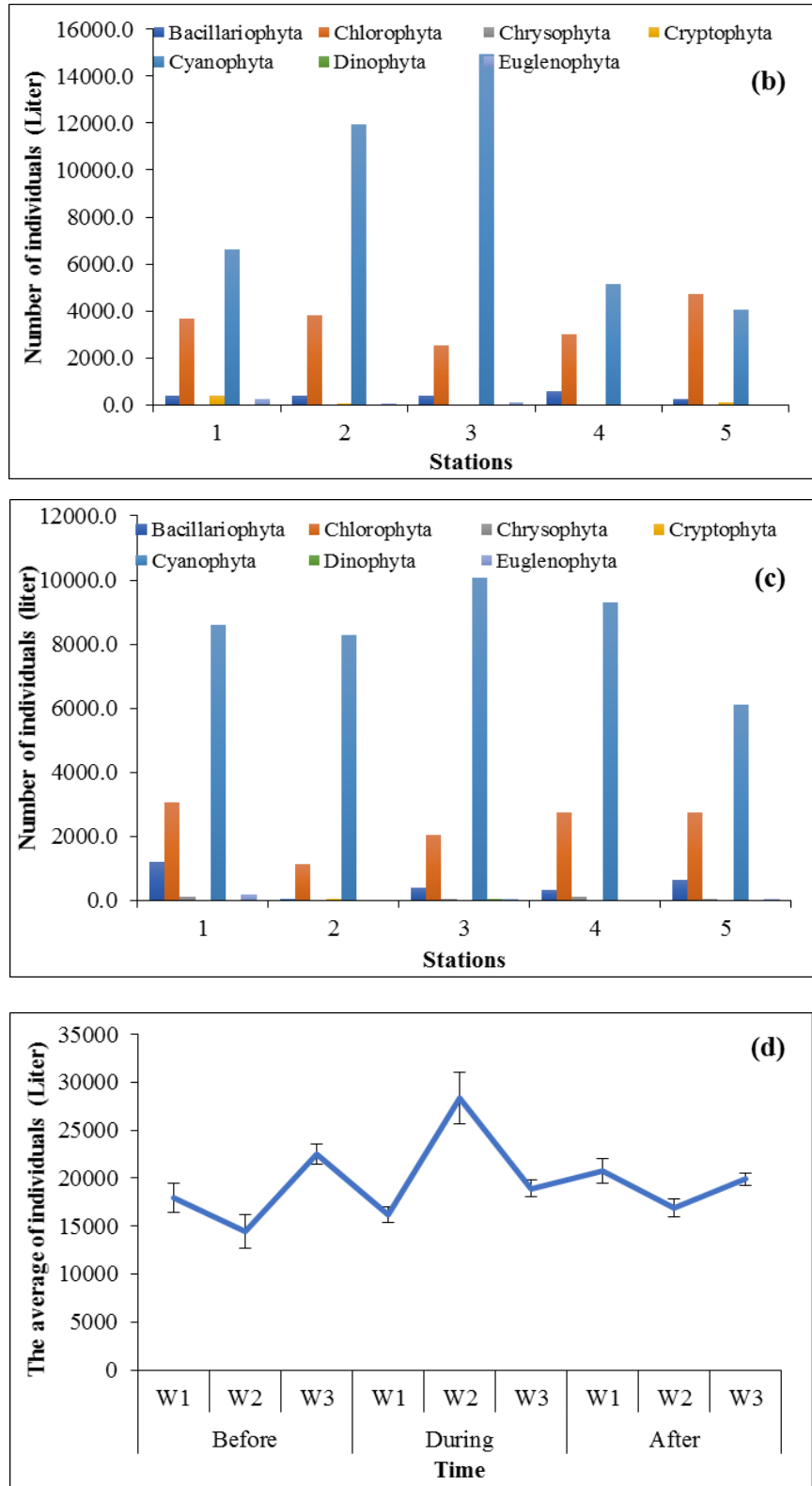Figure 2. Total number divisions of phytoplankton (anova, $p > 0.296$).

Figure 3. The number individuals of phytoplankton on (a) before, (b) during (c) after and (d) average of individuals (ANOVA, *p* > 0.942).
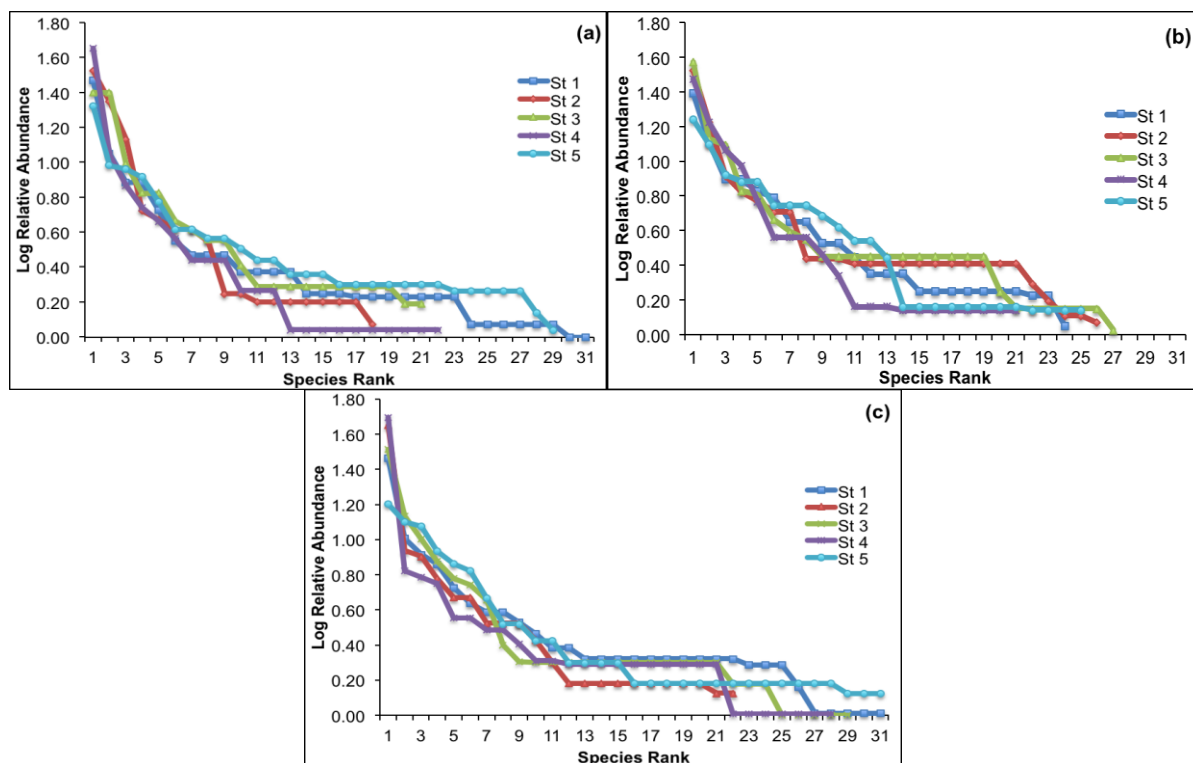
Figure 4. The relative abundance of phytoplankton Situ Gintung (a) before, (b) during and (c) after Ramadan periods

Table 1. Phytoplankton species of Situ Gintung lake before, during and after Ramadan periods.

Divisions	No.	Species	Time		
			B	D	A
	1	*Actinastrum* sp.	+	+	+
	2	*Ankistrodesmus* sp.	+	+	-
	3	*Ankyra* sp.	-	+	-
	4	*Chlamydomonas* sp.	+	+	+
	5	*Chlorella* sp.	+	+	+
	6	*Closterium* sp.	-	+	+
	7	*Coelastrum* sp.	-	+	+
Chlorophyta	8	*Cosmarium* sp.	+	+	+
	9	*Crucigenia fenestrata* Schmidle	-	+	-
	10	*Dictyosphaerium* sp.	-	+	+
	11	*Eudorina elegans*	+	+	+
	12	*Gonium* sp.	+	-	+
	13	*Haematococcus* sp.	-	-	+
	14	*Monoraphidium* sp.	+	+	+
	15	*Oedogonium* sp.	-	+	-

	16	*Pandorina morum* (O.F.Müll.) Bory	+	+	+
	17	*Pleurococcus* sp.	+	-	-
	18	*Scenedesmus acuminatus* (Lagerheim) Chodat	+	-	-
	19	S. *bicaudatus* Debus	+	+	+
	20	S. *obliquus* (Turpin) Kütz	-	+	+
	21	S. *obtusus* Meyen	+	+	+
	22	S. *ornatus* (Lemmerm.) G.M.Sm.	+	+	+
	23	*Selenastrum* sp.	+	+	+
	24	*Sphaerocystis* sp.	+	+	+
	25	*Spirogyra* sp.	-	+	-
	26	*Staurastrum* sp.	-	+	-
	27	*Tetraedron* sp.	+	+	+
	28	*Tetrastrum* sp.	+	+	+
Bacillariophyta	1	*Actinocyclus* sp.	+	+	+
	2	*Actinoptychus* sp.	+	-	-
	3	*Asterionella* sp.	+	-	-
	4	*Aulacodiscus* sp.	+	-	-
	5	*Caloneis* sp.	-	+	-
	6	*Cocconeis pediculus* Ehrenb	+	+	+
	7	*Diatoma* sp.	+	+	+
	8	*Diploneis* sp.	+	+	+
	9	*Fragilaria* sp.	-	+	-
	10	*Navicula* sp.	+	-	-
	11	N. *pelagi* A.W.F. Schmidt	-	+	-
	12	N. *rhynchocephala* Kütz	+	-	-
	13	*Nitzschia acicularis* (Kütz.) W.Sm.	+	+	+
	14	*Rhopaldia* sp.	-	-	+
	15	*Synedra* sp.	-	-	+
Cyanophyta	1	*Anabaena* sp.	+	+	+
	2	*Chroococcus* sp.	+	+	+
	3	*Cylindrospermopsis* sp.	+	+	+
	4	*Gloeocapsa* sp.	+	+	+
	5	*Merismopedia punctata* Meyen	+	+	+
	6	*Merismopedia trolleri* H. Bachm.	-	-	+
	7	*Microcystis aeruginosa* (Kütz.) Kütz.	+	-	+
	8	*Oscillatoria agardhii*	+	-	-
	9	O. *brevis* Kütz. Ex Gomont	+	+	+
	10	O. *princeps* Vaucher ex Gomont	+	+	+
	11	O. *rubescens* De Candolle ex Gomont	+	+	+
Euglenophyta	1	*Euglenoids* sp.	-	+	+

			B	D	A
	2	*Euglena* sp.	+	-	-
	3	*E. proxima* P.A. Dang	+	+	-
	4	*Phacus* sp.	+	+	+
	5	P. *triqueter* (Ehrenb.) Perty	+	-	-
Cryptophyta	1	*Cryptomonas* sp.	+	+	+
	2	*Haematococcus* sp.	+	+	+
	3	*Rhodomonas* sp.	+	-	-
Chrysophyta	1	*Synura* sp.	+	-	+
Dinophyta	1	*Peridinium* sp.	+	-	+
		Total number of species	47	45	43

Note: B: Before, D: During, A: After, (+) present and (-) absent

Table 2. Diversity (H'), dominance (D) and evenness (J') indices phytoplankton of Situ Gintung lake (ANOVA, $p > 0.948$, $p > 0.740$ and $p > 0.841$, respectively).

Indices	Ramadan periods	Station				
		St 1	St 2	St 3	St 4	St 5
H'	Before	1.17	0.89	0.98	0.94	1.24
	During	1.14	1.01	0.96	1.01	1.20
	After	1.17	0.94	1.06	0.94	1.24
D	Before	0.12	0.19	0.15	0.23	0.08
	During	0.11	0.16	0.19	0.15	0.08
	After	0.12	0.23	0.15	0.26	0.08
J'	Before	0.80	0.71	0.74	0.69	0.85
	During	0.82	0.71	0.67	0.76	0.86
	After	0.79	0.71	0.72	0.64	0.83

Notes: Bold of value show minimum and maximum.