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A Preliminary Study of Phytoplankton at Lake Chini, Pahang

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Abstract: A study on species diversity of phytoplankton and its relationship to the lake water quality was conducted at Lake Chini, Pahang. Sampling was conducted twice i.e., 10th July 1999 which is commonly dry period for tropical and 11th December 1999, which is wet season. Quantitative and qualitative sampling was done using the plankton net at the nine selected sampling stations. A total of 81 genus which is consists of 135 species of Bacillariophyta, Cholorphyta, Cyanophyta, Chrysophyta, Euglenophyta and Pyrrophyta division had been identified. Chlorophyta was quantitatively and qualitatively the most dominants division, which was dominated by genus *Staurastrum* spp, *Cosmanbm* spp and *Ankistrodesmus falcatus* (Corda) Ralfs. From the quantitative sampling, the density of phytoplankton had an average of 2129 ind./ml and one way ANOVA analysis (a = 0.05) showed that there is a significant differences between sampling stations, but not significantly different between two season. The Shannon diversity index of phytoplankton was detected ranging between 2.050 to 2.905 and one way ANOVA ((a = 0.05) analysis showed no significant different of this index between season. The water quality of the Lake Chini was within the natural concentration. Only nitrate was detected slightly higher than the natural range ie ranging between 0.9 mg/l to 1.4 mg/l. The correlation test ((a= 0.05) showed that the organisms density and diversity index did not have a significant linear correlation with the physical and chemical water quality. *Ankistrodesmus falcatus* (Corda) Ralfs. found highly abundance in both sampling and has a potential to be used as a biological indicator for the high level of nitrate-nitrogen, however, further study need to be conducted for confirmation.

Key words: Phytoplankton, biological indicator, biodiversity

Introduction

Lake Chini is Malaysian's second largest natural inland lake after Lake Bera. Lake Chini is located in the midst of Pahang Tenggara region, which is about 100 km from Kuantan. This Lake is connected to the Sungai Pahang by a Sungai Chini, which is 4.8 km long and flanked on both banks by overhanging trees which form an attractive canopy over the river in an extremely picturesque and tranquil setting. This natural lake is reported to sustain a high biodiversity of terrestrial and aquatic resources. A number of 138 species of terrestrial flora, 304 species of terrestrial vertebrates and 84 species of fishes were recorded and some of the species had been identified as being rare, endemic and even endangered. Lake Chini is comprises of thirteen open surface water (individual lake) also known as 'laut' by the local indenginous people and encompasses an area of approximately 150 ha (Fig. 1). These water bodies exhibit an extensive surficial growth of lotus *(Nelumbo nucifera)* fringing along lake edges and occasionally covering some of the water surface of the lake. The blooming of lotus create a very aesthetic environment which adds to the attraction for the tourism in the area. However, some parts in vicinity of the lake had been cleared and planted with agricultural plantations. This has changed some of the natural look and environmental quality of the lake. Some of the agricultural activities such as fertilization and land clearance, if not conducted properly, could lead to the deterioration of the water quality.

A study had been conducted to determine the diversity of phytoplankton in the Lake Chini because this micro alga is known to be a good indicator for water quality classification. Furthermore, it is also necessary to have a list of phytoplankton species present in this lake as a baseline data.

Materials and Methods

The sampling was conducted twice on the 10th. July 1999 and 11th. December 1999 respectively. The first sampling was conducted with the aim to determine the algal diversity during the dry season and second sampling was carried out during the wet season in Malaysia. The qualitative sampling was conducted using the Wisconsin plankton net, while quantitative sampling had used the Van Dorn water sampler. The qualitative sampling was only conducted once, whereas quantitative sampling was conducted for both sampling date. A number of nine sampling stations were identified for the purpose (Fig. 1).

For the qualitative sampling, plankton net was slowly towed at constant speed by boat for five minutes. The samples were then transferred into the sampling bottles and preserved with 4% formalin. For the quantitative sampling, water samples were collected approximately 0.5 m below the surface using Van Dorn water sampler. The water samples were transferred into 500 ml sample bottles and preservation was done as above. All samples were kept cool for about 4°C until further taxonomy work is conducted.

Water quality study was conducted by both *in situ* measurement and analysis. The *in situ* measurement was done for dissolved oxygen, pH, conductivity and light penetration. Analysis was done for nitrate, ammonia, colour and orthophosphate using Hach-Kit instruments and reagents. The protocol for analysis was in accordance to the Hach manual. Laboratory works comprises of identification of phytoplankton and quantifying the density of pyhtoplankton. Qualitative samples were concentrated and taxonomic work was conducted using the taxonomic guide book. For the quantitative samples, phytoplankton counting procedure was done. Stemple-Hansen pipette was used to transfer 1 ml of sample into Sedgewich-Rafter counting cell. Three lines in the Sedgewich-Rafter were randomly chosen for the phytoplankton counting. The taxonomic identification and counting were done The Shannon diversity index, Margalef richness index and Pielou eveness index were used to determine the diversity of phytoplankton and to determine the status of the ecosystem. One-way anova and correlation test were also calculated to evaluate the differences and relationship of the phytoplankton diversity and density with regards to lake water quality.

Results and Discussion

Water Quality: Results for water quality for both sampling

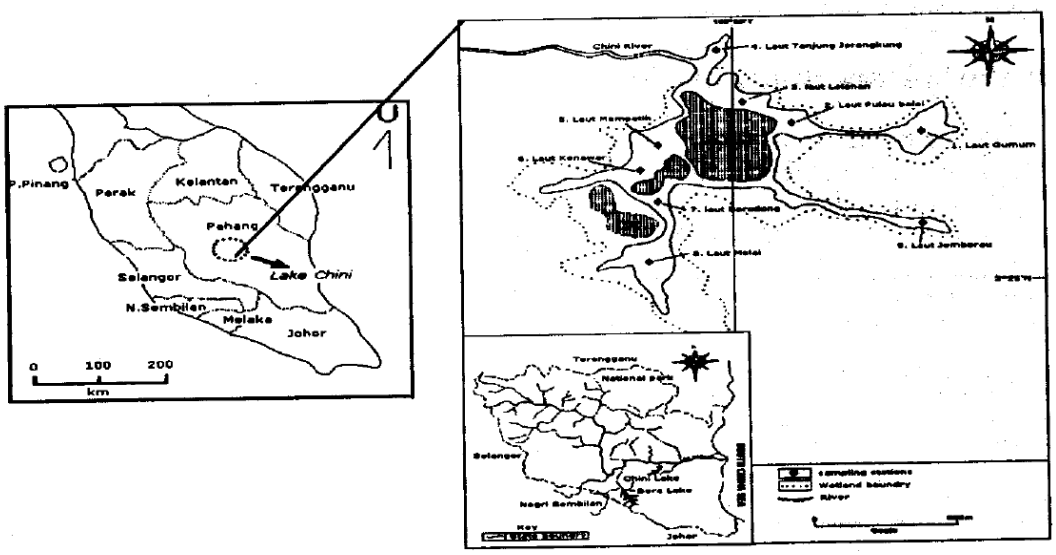

Fig. 1: Lake Chini and Phytoplankton sampling stations

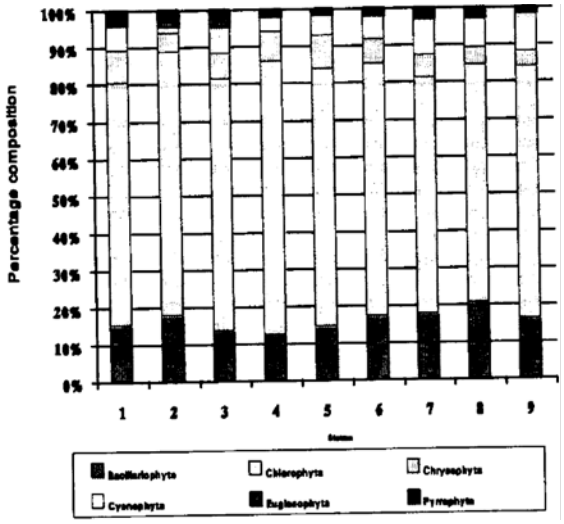

Fig. 2: Percentage of composition of division between sampling station

simultaneously. Density of phytoplankton was calculated using the formula as shown below;

$$\text{No. ind./ml} = \frac{C \times V}{L \times D \times W \times S \times f}$$

Where, C = No of counted cell in the three line
V = Volume cell *Sedgewich-Rafter* (1000 mm^3)
L = Length of the line (50 mm)
D = Depth of each line (1 mm)
W = Wide of each line (0.34 mm)
S = Number of line (3)
F = Dilution factor (0.99 bagi 4% formalin)

Therefore No.ind./ml = C × 19.81

were shown in Table 1. Most of the parameter concentration is within the natural range for the tropical freshwater ecosystem. The dissolved oxygen concentration ranged from 2.76 mg/l to 6.26 mg/l with the mean of 4.91 mg/l. The mean

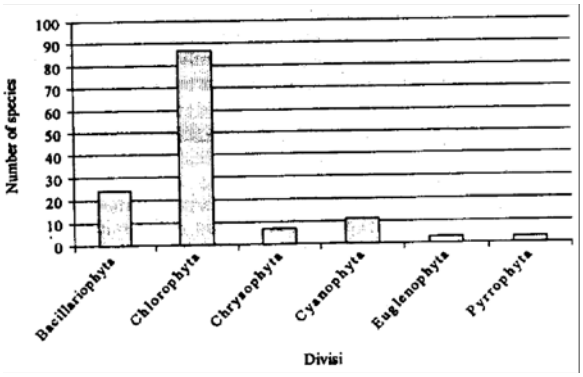

Fig. 3: Number of species for every division

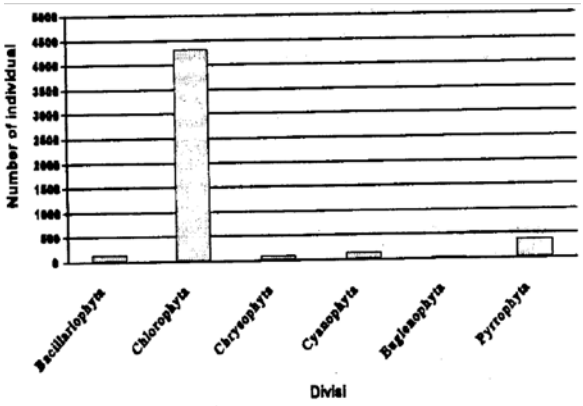

Fig. 4: Number of individual for every division

value is relatively higher as compared to the Lake Bera, which is only 1.90 mg/l as reported by Furtado and Mori (1982). The water is slightly acidic expectedly as a result from the natural biodegradation process at the bottom of the lake. These values falls within the normal range as noted by Robert *et al*. (1974) that the optimum pH for the phytoplankton growth is within 5.0 to 8.5. Light penetration was determined by using the Secchi disc. Light penetration in Lake Chini ranges

Table 1: The mean value for the physical and chemical water quality

Station	Water Quality Parameters								
	Temp. (°C)	pH	Dissolved Oxygen (mg/l)	Conductivity (AS/cm)	Light Penetration (m)	Turbidity (FTU)	Appearance Colour (Pt-Co)	Orthophosphate (mg/l)	Nitrate-nitrogen (mg/l)
1	28.56 ± 0.06	5.65 ± 0.24	4.34 ± 3.38	15.0 ± 2.6	1.20 ± 0.28	10 ± 6	59 ± 1	0.03 ± 0.04	0.9 ± 0.1
2	29.25 ± 1.34	5.90 ± 0.18	4.79 ± 0.58	24.5 ± 7.8	0.25 ± 0.1	30 ± 29	323 ± 1	0.00 ± 0.00	0.7 ± 0.0
3	26.85 ± 0.92	5.75 ± 0.00	4.71 ± 0.10	25.0 ± 10.8	0.68 ± 0.60	38 ± 43	431 ± 3	0.10 ± 0.14	3.1 ± 0.1
4	29.53 ± 0.74	5.67 ± 0.13	4.41 ± 0.62	23.7 ± 2.7	1.30 ± 0.28	6 ± 1	76 ± 1	0.01 ± 0.01	0.8 ± 0.3
5	29.77 ± 0.80	5.71 ± 0.04	4.45 ± 0.28	23.5 ± 3.3	1.25 ± 0.20	7 ± 0	80 ± 1	0.03 t 0.04	0.8 ± 0.1
6	29.60 ± 0.01	5.78 ± 0.41	5.81 ± 0.18	23.7 ± 4.4	2.30 ± 0.28	3 ± 1	38 ± 1	0.01 ± 0.01	1.0 ± 0.0
7	28.34 ± 1.36	6.23 ± 0.22	4.45 ± 0.93	26.1 ± 4.0	1.65 ± 0.10	6 ± 1	70 ± 1	0.03 ± 0.02	0.8 ± 0.4
8	29.96 ± 0.36	6.26 ± 0.61	6.16 ± 0.08	21.4 ± 5.1	2.75 ± 0.12	6 ± 5	32 ± 1	0.01 ± 0.00	1.1 ± 0.3
9	27.50 ± 1.41	5.48 ± 0.62	5.08 ± 2.44	18.4 ± 1.0	2.70 ± 2.40	1 ± 1	37 ± 1	0.02 ± 0.02	2.1 ± 1.2
Mean	28.82 ± 1.08	5.82 ± 0.26	4.91 ± 0.66	22.4 ± 3.6	1.55 ± 0.87	12 ± 13	127 ± 145	0.02 ± 0.03	1.1 ± 0.8

Table 2: The anova analysis for the water quality test between stations and sampling

Parameter	Source Variation							
	Between Station				Between Sampling			
	df	P	F Analysis	F Crit.	df	P	F Analysis	F Crit.
Temperature	8	0.0801	2.7016	3.2296	1	0.8968	0.0174	4.4940
pH	8	0.4118	1,1594	3.2296	1	0.7193	0.1338	4.4940
Dissolved Oxygen	8	0.9542	0.2760	3.7257	1	0.0533	4.4545	4.6001
Conductivity	8	0.5781	0.8612	3.2296	1	0.1170	2.7462	4.4940
Light Penetration	8	0.5912	0.8697	4.8183	1	0.6807	0.1779	4.7472
Turbidity	8	0.4625	1.0585	3.2296	1	0.2841	1.2284	4.4940
Orthophosphate	8	0.6932	0.6913	3.2296	1	0.0659	3.8975	4.4940
N it rat-n itrog en	8	0.0656	0.3227	3.7257	1	0.1889	1.9074	4.6001

Table 3: Checklist of phytoplankton from the quantitative sampling

Species	Station									
	1	2	3	4	5	6	7	8	9	Total
BACILLARIOPHYTA										
Amphora ovalis Kutz.	1	2	3	2	0	1	0	3	1	13
Cymbella cristula (Hempr.) Kirch.	0	0	0	1	3	0	0	2	0	6
Fragflaria sp.	0	1	3	5	6	3	3	1	0	22
Frustulia javanicaHustedt.	3	0	1	1	0	1	1	1	0	8
Frustulia rhomboides (Ehr.) De Toni	0	0	0	0	3	0	0	1	0	4
Gomphonema vibrio Ehr.	2	2	1	1	3	8	0	2	2	21
Melosira granulata (Ehr.) Ralfs.	1	0	0	0	0	0	0	0	0	1
Navicula radiosa Kutz.	6	2	4	6	4	4	2	5	0	33
Nitzschia sigma (Kutz.) W. Smith	1	0	0	0	0	0	0	0	0	1
Nitzschia sp. # 1	1	0	0	3	0	0	0	0	0	4
Pinnularia viridis	4	0	0	0	0	0	0	2	1	7
Rhizosolenia eriensis H. L. Smith	0	0	0	0	0	1	1	0	0	2
CHLOROPHYTA										
Ankistrodesmus falcatus (Corda) Ralfs	317	249	303	310	387	180	170	16	1	1933
Arthrodesmus convergen Ehr.	1	2	0	0	0	0	0	5	2	10
Arthrodesmus incus var. *extensus* Anderss.	73	34	12	7	7	3	6	0	0	142
Arthrodesmus octocorne Ehr.	2	6	3	4	11	8	18	0	0	52
Arthrodesmus phimus Turn.	6	0	0	0	0	0	0	0	0	6
Bohlinia echidna (Bohlin) Lemm.	5	1	0	0	0	0	0	0	0	6
Botryococcus braund Kutz.	1	0	0	0	0	0	0	0	0	1
Chlamydomonas reinhardtii Dang.	2	3	1	0	1	0	0	2	0	9
Chlorella variegates Beijerinck	5	2	1	0	0	0	0	0	1	9
Chodatella longiseta (Lemm.)	10	5	6	5	3	13	8	2	0	52
Closterium parvulum var. *majus* West.	2	0	2	1	4	8	2	2	1	22
Coelastrum sp.	0	0	0	0	0	1	0	0	0	1
Cosmarium bioculaturn	26	7	5	1	0	4	1	6	0	50
Cosmarium contractum Kirchn.	11	5	2	11	17	3	7	2	2	60
Cosmarium margaritiferum Meneoh	1	0	0	0	0	0	0	1	0	2
Cosmarium margaritatum (Lund.) Roy & Bliss	0	2	1	1	0	2	0	0	0	6
Cosmarium melanosporumArch.	0	0	0	0	0	0	0	2	0	2
Cosmarium moniforme (Turp.) Ralfs	9	8	3	1	4	6	4	16	0	51

Cosmarium obsoletum	0	1	0	1	0	0	0	0	0	2
Cosmarium praemorsumBreb.	0	0	0	0	0	0	0	2	0	2
Cosmarium sp. # 3	0	0	0	0	0	1	0	3	0	4
Crucigenia rectangularis (Nag.) Gay.	4	18	31	84	101	94	59	17	8	416
Dictyosphaerium pulchellum Wood.	2	8	9	0	3	0	3	2	0	27
Dispora crucigenioides Printz.	1	2	1	2	2	1	1	97	15	122
Euastrum sp. # 1	0	0	0	0	0	2	0	0	1	3
Eudorina sp.	0	1	1	0	2	0	0	0	0	4
Gonatozygon aculeatum Nast.	0	0	0	1	0	1	0	4	0	6
Haematococcus sp.	7	1	5	7	2	5	4	3	0	34
Kirchneriella lunaris (Kirch.) Moebius	0	1	0	5	3	5	10	0	0	24
Kirchneriella obesa (W. West) Schmidle	0	2	4	6	0	2	4	1	0	19
Lobomonas ampla Pascher	2	9	8	11	33	46	21	3	1	134
Miscrasterias sp. # 1	0	0	0	0	1	1	0	0	0	2
Nephrocytium lunatum West.	8	19	15	9	4	7	5	22	3	92
Nephrocytium obesum W. & W	0	5	2	6	7	15	7	4	0	46
Oocystis eremosphaeria G. M. Smith	3	3	3	1	0	2	2	0	0	14
Pediastrum duplex var. *gracilimum W. & W.*	0	1	0	0	0	0	0	0	0	1
Planktosphaeria gelatinosa G. M. Smith	0	0	1	2	0	3	0	1	6	13
Quadrigula chodatii	0	0	0	0	0	3	0	0	0	3
Radiococcus nimbatus(de Wild)	1	0	1	0	0	1	0	0	1	4
Scenedesmus arcuatus var. *platydisca* G. M. Smith	0	0	2	4	1	0	1	0	0	8
Scenedesmus bijuga	8	5	6	6	10	12	6	5	0	58
Sphaeroplea annulian (Roth) Ag.	0	0	0	0	0	0	6	0	0	6
Spondylosium plenum (Wolle) W. & W.	1	0	1	0	0	0	0	0	0	2
Staurastrum curvaturn	7	12	4	0	0	1	0	0	0	24
Staurastrum limneticum var. *cornutum* G. M. Smith	5	1	0	0	0	0	0	1	0	7
Staurastrum paradoxum Mayen	166	59	29	15	16	7	7	9	2	310
Staurastrum pseudopelagicum	0	0	0	1	0	0	0	0	0	1
Staurastrum punculatum	0	0	0	1	0	0	0	0	0	1
Staurastrum sp.# 3	0	1	0	0	0	0	0	0	0	1
Staurastrum sp.# 4	1	0	0	0	1	1	0	0	0	3
Staurastrum sp.# 6	0	0	0	1	0	0	0	0	0	1
Staurastrum sp.# 8	21	8	14	5	10	14	6	3	0	81
Staurastrum sp.# 9	115	35	14	14	13	4	7	4	0	206
Staurastrum sp.# 10	44	9	1	5	1	3	0	1	0	64
Staurastrum sp. # 11	1	0	0	0	0	0	1	0	1	3
Staurodesmus jaculiferus	80	16	5	6	1	3	1	3	0	115
Tetradron caudatum (Cords) Hansg.	2	0	1	4	2	8	3	0	1	21
CHRYSOPHYTA										
Centritractus belanophorus Lemm.	3	1	3	0	4	3	4	0	1	19
Dinobryon bavaticum Imhof	0	0	0	0	0	1	1	1	0	3
Dinobryon sertulata Ehr.	5	1	0	1	0	0	0	0	0	7
Mallomonas caudata var. *macrolepis* Conrad.	5	0	2	5	5	6	5	10	1	39
Mallomonas producta Iwanoff	0	0	0	0	1	0	0	0	0	1
Trachelomonas sp.	0	0	0	1	0	0	0	0	0	1
CYANOPHYTA										
Aphanotheca castagnei (Breb.) Rab.	0	0	0	0	0	0	0	0	38	38
Aphanotheca clathrata W. & G. S. West	0	0	0	0	0	1	0	0	0	1
Coelosphaerium naegelianum	1	0	0	1	1	1	0	0	0	4
Lyngbya birgei G. M. Smith	0	0	0	0	0	0	8	0	0	8
Microcystis aeruginosa Kutz. *emend* Elenkin	0	0	9	0	0	0	0	1	0	10
Microcystis flos-aquae (Wittr.) Kirch.	0	0	0	0	0	0	0	2	0	2
Polycystis aeruginosa Kutz.	0	2	8	5	2	5	5	40	0	67
EUGLENOPHYTA										
Euglena sp.	0	1	1	1	1	2	1	0	0	7
Phacus sp.	0	1	0	2	1	0	2	0	0	6
PYRROPHYTA										
Massartia sp.	172	28	15	15	9	14	20	18	9	300
Peridinium limbatum Lemm.	0	0	1	1	0	1	3	1	2	9
Peridinium wisconsinense Eddy.	22	3	0	6	2	9	3	0	1	46
Total	1177	585	548	595	692	531	429	329	102	4988

between 0.25 to 2.70 m, with an average of 1.55 m. Stations located close to the Sungai Chini allow lower light penetration due to the turbid water flushing in from the Sungai Pahang especially during monson season.

Lake Chini exhibits a slightly high concentration for nitrate. Average concentration for nitrate is 1.1 mg/l. This value was found to be higher than Lake Bera (Furtado and Mori, 1982) and other commercial lake such as Aman Lake, Kundang Lake and also Rawang Lake which is 0.059 mg/l, 0.02 mg/l, 0.01 mg/l and 0.02 mg/l (Sulaiman *et al.,* 1991) respectively. Orthophosphate concentration was slightly lower as compared to the above mentioned lakes. The mean value is 0.02 mg/l and is within the natural concentration.

One-way ANOVA analysis showed that, there is no

Table 4: Diversity index for nine sampling stations

Station	Diversiti Index	Evence Index	Richness Index
1	2.596	0.660	6.782
2	2.612	0.671	7.350
3	2.300	0.594	7.328
4	2.303	0.586	7.736
5	2.050	0.542	6.511
6	2.764	0.690	8.529
7	2.668	0.701	7.144
8	2.905	0.750	7.930
9	2.461	0.755	5.259

significance difference of water quality parameters obtained between sampling and between sampling. This showed that during this study, Lake Chini water quality was not significantly influenced by the changes of the season (Table 2).

Phytoplankton

Qualitative Sampling: A number of six divisions of phytplankton were detected in these studies, which were namely Bacillariophyta, Chlorophyta, Chrysophyta, Cyanophyta, Euglenophyta and Pyrrophyta. The percentage of division was not significantly different between sampling stations (Fig. 2). One hundred and thirty five species of phytoplankton were recorded in this study. Cholorphyta had the highest diversity, which forms 65% of the total species detected in this study (Fig. 3). The diversity of this division arranged by order were Chiorococcales, Conjugales Volvocales and Sphaeropleales that is 58.62%, 29.89, 10.34 and 1.15% of the total species in the division respectively. The most dominant general from the Conjugales order are *Arthrodesmus, Bambusina, Closterium, Cosmarium, Euastrum, Gonatozygon, Hyalotheca, Micrasterias, Pleurotaenium, Spondylosium, Staurastrum, Triploceras,* dan *Xanthidium, Staurastrum dan Cosmarium. Staurastrum* and *Cosmarium*.

Round (1973) found that general of *Closterium, Xanthidium, Micrasterias, Cosmarium* are dominant in the weak acid water body, whereas *Staurastrum* normally dominants in the acidic water body. This study showed more or less the same result as above.

Bacillariophyta is the second highest diversity of phytoplankton. From the 24 species identified, order Pennales contribute 87% and Centrales was 13%. Pennales comprises of general *Amphora, Cymbella, Eunotia, Fragilaria, Frustulia, Gomphonema, Navicula, Nitzschia, Pinnularia, Stauroneis dan Surirella,* whereas Centrales dominated by *Coscinodiscus, Melosira* dan *Rhizosolenia*.

The diversity of phytoplankton from Lake Chini found to be more or less the same with the Lake Bera as studied by Furtado and Mori (1982). Both natural lakes dominated by Chlorophyta (desmid) and Bacillariophyta.

Quantitative Sampling: Four thousand nine hundred and eighty eight individuals of phytoplankton were counted (Table 3). Chlorophyta showed the highest population density, which is 86.17% of the community for the both sampling. Pyrrophyta was second most abundance followed by Cyanophyta but their contribution were very small as compared to the Chlorophyta (Fig. 4).

From the first sampling, Order Chloroccocales, Conjugales, Volvocales and Phaeropleales from Chlorophyta were dominants and contribute 66.78%, 28.87%, 4.21% and 0.14% of the respectively. *Ankistrodesmus falcatus* (Corda) Ralfs was the most dominant species from this division, followed by *Crucigenia rectangularis* (Nag.) Gay and *Dispora crucigeniodes* Printz.

However, second sampling showed the decrease of order Chloroccocales density and replaced by order Conjugales(desmid). Chloroccocales was reduced from 74.24% to 54.68% of total individual. Desmid density was increased from 20.84% to 41.85% that was contributed by three dominant general *ie. Stauratrum, Cosmarium* and *Staurodesmus jaculiferus*.

Chlorophyta showed the highest density and diversity for the eight of sampling stations and for both sampling. Only stations 9 showed the different result. Species of *Aphanotheca castagnei* (Bre.) Rab. from the Chyanophyta was dominants at this stations. Stations 9 is located quite far from the Chini River mouth and not significantly affected by the changes of low and hide tide of Pahang River. The light penetration at this station was very high which was four times than others a station and the water was very clear. Chyanophyta was found to be dominants at clear water. The same results was obtained by Haberyan *et al*. (1995), from the study of several Costan Rican lake. Correlation test showed that there is no strong correlation detected between physico-chemical parameters with the density of phytoplankton. The physico-chemical parameters were not significantly change between sampling and stations. This make the correlation test is slightly difficult to observe. The Shannon diversity index, Pielou eveness index and Margalef richness index were ranging between 2.050 to 2.905, 0.542 to 0.755 and 5.259 to 8.529 respectively (Table 4). As referred to these values showed that Lake Chini experience environmental stress in the middle stage. Correlation test (a = 0.05) also showed no strong correlation between diversity index and physico-chemical parameters.

Division Chlorophyta was the most abundance and had the highest diversity and density in the Lake Chini, followed by the Pyrrophyta and Cyanophyta. *Ankistrodesmus falcatus* (Cords) Ralfs was the most dominant species from this division, followed by *Crucigenia rectangularis* (Nag.) Gay and *Dispora crucigeniodes* Printz. Cyanophyta was found to have a good adaptation for the clear water rather than turbid water. The water quality was good and no positive correlation was detected as regards with phytoplankton community.

Aknowledgement

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