UNIVERSITI PUTRA MALAYSIA

DISTRIBUTION AND DIVERSITY OF PHYTOPLANKTON IN A TROPICAL MAN-MADE LAKE, PUTRAJAYA, MALAYSIA

ASMA' JAMAL

IB 2016 28

DISTRIBUTION AND DIVERSITY OF PHYTOPLANKTON IN A TROPICAL MAN-MADE LAKE, PUTRAJAYA, MALAYSIA

By

ASMA' BINTI JAMAL

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

May 2015

This work is dedicated to

Supporting role models
Jamal Othman and *Siti Zulaihah Abu Sari*
Hafidzi Md Noor and *Zuraidah Kornain*

Life pleasures
Umar Mukhtar
Wafa' Amani

Life companion
Mohd Qayyim Hafidzi

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

DISTRIBUTION AND DIVERSITY OF PHYTOPLANKTON IN A TROPICAL MAN-MADE LAKE, PUTRAJAYA, MALAYSIA

By

ASMA' BINTI JAMAL

May 2015

Chairperson : Professor Fatimah Md Yusoff, PhD
Faculty : Institute of Bioscience

A study on phytoplankton community in a tropical man-made lake, Putrajaya Lake was carried out from October 2009 to September 2010. The study was conducted to examine the phytoplankton composition, distribution and diversity in different zones of the lake, and in different seasons. Monthly phytoplankton samples were collected at three selected stations representing three different lake zones, namely Station 1 (littoral zone), Station 2 (sub-littoral zone) and Station 3 (limnetic zone). Phytoplankton samples from each station were preserved, identified and enumerated. Physico-chemical parameters such as water temperature, pH, conductivity and dissolved oxygen were measured *in situ*. Meteorological data were obtained from the Putrajaya Corporation Database Centre.

Differences in the composition and diversity of the community across zones spatially and vertically were analysed by using multivariate test procedures. A total of 148 species from 77 genera were recorded for the Putrajaya Lake during the study period. The seven identified groups were Chlorophyta (59% of the total abundance), Pyrrhophyta (15%), Cyanobacteria (11%), Bacillariophyceae (9%), Chrysophyceae (3%), Cryptophyta (2%) and Euglenophyta (1%). The highest total mean density of phytoplankton was recorded in the limnetic zone (433.94 ± 18.29 cells ml^{-1}), followed by sub-littoral (292.94 ± 18.61 cells ml^{-1}) and littoral zone (199.58 ± 13.56 cells ml^{-1}). Average similarity within zones in descending order was limnetic zone (58.5%), sub-littoral zone (53.7%) and littoral zone (52.1%). According to zones, *Peridinium* had the highest density in littoral and sub-littoral zones although the dinoflagellates were not the dominant phytoplankton group, whereas *Staurastrum* dominated the limnetic zone. There was a significant difference in the Shannon-Wiener diversity index for phytoplankton diversity and abundance in all three zones ($p < 0.05$). Limnetic zone demonstrated the highest species diversity (H'=3.48 ± 0.021) compared to other zones.

In terms of depth distribution, the highest phytoplankton density was found at 1.5 m depth (366.03 ± 33.37 cells ml^{-1}) combining all stations. However, the highest species

diversity was observed at 2.0 m depth (3.54 ± 0.04). Nonetheless, densities and species diversity values at different depths were not significantly different ($p > 0.5$).

Two distinct groups consisted of limnetic and littoral-sub-littoral zones at 83% were obtained from the dendrogram. SIMPER average dissimilarity was highest between littoral and limnetic zone (50.8%) with *Staurastrum* as the most discriminating genus (6.7%). Sub-littoral species dominated both littoral and limnetic phytoplankton communities suggesting that sub-littoral zone acts as an interphase for phytoplankton adaptation and migration between the two different zones.

Phytoplankton community in Putrajaya Lake did not show distinct seasonal pattern. Rainfall had low influence on the phytoplankton community structure ($r = 0.168$) and the ANOSIM R value ($R = 0.21$) indicated strong overlapping of phytoplankton communities found during the wet and dry seasons. Average dissimilarity between the two seasons was 49.8% whilst average similarity within each wet and dry seasons were 55.0% and 58.5%, respectively. Shannon-Wiener diversity index during the wet season was higher than the dry season, but not significantly different ($p > 0.05$).

Physical parameters such as water transparency, temperature, pH, dissolved oxygen, and conductivity were found to be important factors characterizing each zone and influencing the phytoplankton composition ($p < 0.01$). The genus *Staurastrum* and *Peridinium* which were found dominant in the present study may indicate the water trophic as oligotrophic. Nevertheless the rise and sink of chrysophytes at a certain period of time may suggest the interchanging trophic water between oligotrophic to mesotrophic. The findings suggest that spatial and temporal distribution and diversity of the phytoplankton community can be affected significantly by local lake zonation characterized by environmental variations.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Sarjana Sains

TABURAN DAN KEPELBAGAIAN FITOPLANKTON DI TASIK TROPIKAL BUATAN MANUSIA, PUTRAJAYA, MALAYSIA

Oleh

ASMA' BINTI JAMAL

Mei 2015

Pengerusi : Professor Fatimah Md. Yusoff, PhD
Fakulti : Institut Biosains

Satu kajian mengenai komuniti fitoplankton di sebuah tasik tropikal buatan manusia, Tasik Putrajaya, Malaysia telah dijalankan sejak Oktober 2009 sehingga September 2010. Kajian tersebut dilaksanakan untuk mengkaji komposisi, distribusi dan variasi fitoplankton mengikut faktor perbezaan zon tasik dan perbezaan musim. Sampel bulanan fitoplankton telah diambil di tiga stesen terpilih yang mewakili tiga zon berbeza sesebuah tasik, iaitu Stesen 1 (zon litoral), Stesen 2 (zon sub-litoral) dan Stesen 3 (zon limnetik). Sampel fitoplankton dari setiap stesen telah diawet, dikenalpasti dan dikira. Parameter fisiko-kimia seperti suhu air, pH, konduktiviti dan oksigen terlarut telah diukur secara *in situ*. Data meteorologi turut didapati dari pangkalan data Perbadanan Putrajaya.

Perbezaan dari segi komposisi dan kepelbagaian komuniti fitoplankton merentas zon mengikut ruang dan secara menegak telah dianalisa menggunakan prosedur ujian multivariat. Sejumlah 148 spesies daripada 77 genera telah direkod. Tujuh kumpulan yang telah dikenal pasti adalah Chlorophyta (59% daripada jumlah keseluruhan fitoplankton), Pyrrhophyta (15%), Cyanobacteria (11%), Bacillariophyceae (9%), Chrysophyceae (3%), Cryptophyta (2%) dan Euglenophyta (1%). Purata kepadatan fitoplankton yang tertinggi telah direkod di zon limnetik (433.94 ± 18.29 sel ml^{-1}), diikuti oleh zon sublitoral (292.94 ± 18.61 sel ml^{-1}) dan zon litoral (199.58 ±13.56 sel ml^{-1}). Purata persamaan dalam lingkungan zon secara menurun adalah zon limnetik (58.5%), zon sublitoral (53.7%) dan zon litoral (52.1%). Mengikut zon, *Peridinium* mencatat limpahan tertinggi di zon litoral dan zon sublitoral meskipun dinoflagella bukan merupakan kumpulan dominan, sementara *Staurastrum* mendominasi zon limnetik. Terdapat perbezaan signifikan pada indeks kepelbagaian Shannon-Wiener untuk kepelbagaian dan limpahan fitoplankton di ketiga-tiga zon ($p < 0.05$). Zon limnetik menunjukkan indeks kepelbagaian tertinggi (H'=3.48 ± 0.021) berbanding zon lain.

Dari aspek distribusi menegak, limpahan fitoplankton tertinggi merentas zon adalah di kedalaman 1.5 meter (366.03 ± 33.37 sel ml^{-1}). Walau bagaimanapun, kepelbagaian

indeks menegak yang tertinggi diperhatikan di kedalaman 2.0 m (3.54 ± 0.04). Sekalipun begitu, limpahan dan kepelbagaian indeks fitoplankton merentas faktor kedalaman didapati tidak signifikan ($p > 0.05$).

Dua kumpulan yang terdiri daripada kumpulan zon limnetik dan zon litoral-sublitoral di peratusan 83% telah diperolehi daripada dendrogram. Purata ketidaksamaan SIMPER didapati tertinggi di antara zon litoral dengan zon limnetik (50.8) dengan *Staurastrum* sebagai genus utama yang membezakan (6.7%). Spesies zon sublitoral yang diperhatikan mendominasi kedua-dua zon litoral dan limnetik menggambarkan zon sublitoral berperanan sebagai zon interfasa untuk fitoplankton mengadaptasi dan bermigrasi antara dua zon yang berbeza.

Komuniti fitoplankton di Tasik Putrajaya tidak menunjukkan corak perbezaan ketara antara dua musim. Air hujan memberikan pengaruh yang rendah keatas struktur komuniti fitoplankton ($r = 0.168$) dan bacaan nilai R ANOSIM ($R = 0.21$) mengindikasikan pertindihan yang ketara antara komuniti fitoplankton yang dijumpai semasa musim hujan dan musim kering. Purata ketidaksamaan antara dua musim adalah 49.8% sementara purata persamaan dalam lingkungan setiap musim adalah masing-masing 55.0% dan 58.5% bagi musim hujan dan musim kering. Indeks kepelbagaian Shannon-Wiener semasa musim hujan lebih tinggi dari indeks kepelbagaian semasa musim kering tetapi tidak berbeza secara signifikan ($p > 0.05$).

Parameter fizikal seperti transpirasi air, suhu, pH, oksigen terlarut dan konduktiviti didapati adalah faktor-faktor penting dalam mencirikan setiap zon dan mempengaruhi komposisi fitoplankton ($p < 0.01$). Genus *Staurastrum* dan *Peridinium* yang didapati dominan dalam kajian ini berkemungkinan mengindikasikan trofik air sebagai oligotrofik, Walau bagaimanapun, peningkatan dan penurunan krisofita pada waktu tertentu mencadangkan perubahan trofik antara oligotrofik kepada mesotrofik. Kajian ini mencadangkan bahawa distribusi dan kepelbagaian komuniti fitoplankton merentas ruang dan masa boleh dipengaruhi secara signifikan oleh penzonan sesebuah tasik yang dicirikan oleh variasi persekitaran.

ACKNOWLEDGEMENTS

I wish to express my utmost appreciation and indebtedness to my advisory committee chairperson, Professor Dr. Fatimah Md. Yusoff who provided me with every academic need; valuable guide, helpful suggestions, constructive comments and motivation, untiring support and encouragement. Sincere thankfulness also goes to the members of my advisory committee, Prof Dato' Dr Shariff Mohamed and Dr Sanjoy Banerjee for providing critical reviews, comments and suggestions needed.

Special thanks go to Mr. Perumal, En. Azmi, Suhayati, Siti Zubaidah and Dora for their assistance and guide during the early days of my MSc programme. To Hafizah Osman, Siti Balqis, Nicholas, thank you for the friendship, time spared and companionship during my field sampling days. Not to forget, to Adibah, and Kamarul Bahri for helping out the extended works I needed to complete although I know all of you have your own heavy workloads needed to attend to. My gratefulness also extends to the newly found friends and acquaintances of Laboratory of Marine Biotechnology (MARSLAB) for the intellectual discussions, joyful moments and being inspiring exemplars; Norasamullah, Nurul Farahin, Nurul Huda, Hanis, Wan, Izni, Sasi, Fareha, Sook kun, Soochirn, Elsie, Dr. Helena, Dr. Nagao, Dr. Aminurrahman and Dr. Srikanth. Being part of the MARSLAB community and able to share the knowledge attained in aspects of science nor life itself, in happiness and tears, will become a pleasant memory in life. My recognition also goes to the staffs in the microscopy unit of Institute Bioscience (IBS) for their contribution in the pursuit of completing this thesis.

Above all, gratitude to the Almighty, for His mercy, will and power, I am here.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follow:

Fatimah Md. Yusoff, PhD
Professor
Institute of Bioscience
Universiti Putra Malaysia
(Chairperson)

Dato' Mohamed Shariff Mohamed Din, PhD
Professor
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Member)

Sanjoy Banerjee, PhD
Fellow researcher
Institute of Bioscience
Universiti Putra Malaysia
(Member)

____
BUJANG KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature: ______________________

Name of Chairman of Supervisory Committee: Professor Fatimah Md. Yusoff

Signature: ______________________

Name of Member of Supervisory Committee: Professor Dato' Mohamed Shariff Mohamed Din

Signature: ______________________

Name of Member of Supervisory Committee: Dr. Sanjoy Banerjee

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

µm	Micrometer
µS	Micro-semen
2-D	Two dimensional
ANOSIM	Analysis of similarity
ANOVA	Analysis of variance
cm	Centimeter
g	Gram
H’	Shannon-Wiener diversity index
ha	Hectare
hrs	Hours
I	Iodine
J’	Pielou’s species evenness index
KI	Potassium iodide
km	Kilometer
L	Litre
m	Meter
$m\ s^{-1}$	Meter persecond
ml	Milli-litre
mm	Millimeter
n	Number of samples
NAHRIM	National Hydraulic Research Institute of Malaysia
NMDS	Non-metric multidimensional scaling
^oC	Degrees celsius
PRIMER	Plymouth routines in multivariate ecological research
Sim	Similarity
SD	Starndard deviation
SEM	Scanning electron microscope
SPSS	Statistical package for the social sciences

CHAPTER 1

INTRODUCTION

Phytoplankton constitutes the basic component in the aquatic ecosystem (Ghosh et al., 2012). They are photosynthetic free floating microorganisms that are mostly found in various types of water bodies. The contribution of phytoplankton as a minute creature to the humankind is undeniable. They stand in the baseline of the aquatic food chain as the primary producer, thus offering significant information on the aquatic ecosystem condition (McCormick and Cairns, 1994). Phytoplankton occupies the water which covers 70% of the biosphere, thus it is also regarded as a significant contributor to oxygen production, fixing 40% of earth's carbon (Post et al., 1990). Recent technology adopted the ecological benefit of phytoplankton by installing an algae farm on a highway overpass to absorb car emissions while augmented by sunlight, a form of air pollutant filter (Lexie, 2014).

The combinations of physical, chemical and biological factors largely influence the distribution of phytoplankton community and its composition. Their variation and distribution within the water column depends on the availability of nutrients, temperature, light intensity, salinity, pH and other limnological attributes (George and Heaney, 1978). Variance in these attributes along space and time results in phytoplankton heterogeneity vertically and horizontally as well as established periodicity (Klausmeier and Litchman, 2001). Lake hydrographic and its geographical location also have an impact to the distribution of phytoplankton (Lewis, 1987; Shiel and Williams, 1990; Vyverman, 1996). Previous studies which showed responsive behaviour demonstrated by the phytoplankton community enable the phytoplankton to be important biological tool in monitoring the ecological health of water bodies.

1.1 Background of the study

Lake represents a very small fraction (0.009%) of the total water content of the biosphere compared to oceans (97%) (Băgăcean and Viorel, 2014). Freshwater from many aspects are of vital importance to human and their livelihood, a fact that had led to surveying and monitoring programmes for environmental protection and sustainability. In many cases, the analysis of phytoplankton community structure is related to the practical problems of a lake and had been used as an indicator in water quality analysis and eutrophic assessments. The adoption of phytoplankton as an environmental indicator had started since the mid-19th century (Dokulil et al., 2003). Phytoplankton respond rapidly and predictably to a wide range of pollutants, thus providing potentially useful early warning signals of deteriorating conditions and the possible causes (McCormick and Cairns, 1994; Stevenson et al., 2003).

Lakes which are categorized as tropical are far less numerous than temperate lakes, which might cause the study of tropical inland waters being predominated and influenced by the understanding of inland waters from higher latitude (Lewis, 1996).

Thus tropical limnology would not be of extraordinary importance if tropical aquatic environments could be understood readily from the principles applied to temperate systems (Lewis, 1987). Many assumptions, findings and conclusions had been made on tropical system; some might contradict one another (Melack, 1979; Ashton, 1985; Lewis, 1987; 1996; Stomp et al., 2011). It can be said that the phytoplankton communities in the lower latitude lakes are no more complex than the higher latitudes, in contrast with the terrestrial communities which have established a good understanding of diversity pattern. The corresponding fluctuations of phytoplankton in their abundance and dynamics are governed by localized climatic events consisting of physical, chemical and biotic factors.

Putrajaya Lake is a tropical man-made lake created in the year 2007 located in the heart of the Federal Government Administrative Centre of Malaysia. It covers a surface area of 7.5 km2 (NAHRIM, 2005) with a maximum depth of 14 m and an average annual rainfall of 2839 mm. The lake system was created from the flooding of Sungai Chuau and Sungai Bisa valleys, integrated with yet the biggest constructed wetlands in the tropics, occupying more than 600 ha of the landform in Putrajaya (Hijjas et al., 2001). It becomes the most significant visual and landscape feature of the administrative city and supports many water activities. Thus Putrajaya Lake is under constant monitoring by the Perbadanan of Putrajaya to maintain the lake ecosystem and its water quality.

1.2 Problem statement

The ecology of tropical phytoplankton started to gain attention since 1928 (Thienemann, 1954) but published works and understandings in the principles are still scarce and fragmented despite of the accumulating literatures (Lewis, 1987). Compared to the comprehensively compiled works of the temperate and high latitudes such as The Freshwater of Algal Flora of the British Isles (John et al., 2002), Freshwater Algae of North America (Wehr, 2002), the PEG-model proposed by Sommer (1986) and the ongoing online algaeBase web founded by Michael Guiry since year 1996, the knowledge on phytoplankton in tropical waters is still diffuse and fragmentary. Despite the increasing literatures and good documentation on tropical inland waters (Lewis, 1978a; 1978b; 1978c; Furtado and Mori, 1982; Kalff and Watson, 1986; Ndebele-Murisa et al., 2010), there is most likely that understanding of the researchers on the water dynamics is more or less influenced by the literatures of the higher latitudes (Lewis, 1987) although it is least likely evitable.

In addition, not many tropical freshwater studies were done solely to understand the tropical ecology of phytoplankton especially in man-made lakes. Most studies that had been done on the phytoplankton of Putrajaya Lake utilize the phytoplankton community in monitoring and modelling programmes (Malek et al., 2009; Malek et al., 2012; Sorayya et al., 2012). By far there is no published study in Putrajaya Lake that focuses on the biodiversity of the phytoplankton community itself, which is very important for ecosystem studies.

The diversity of phytoplankton has never been an explicit discovery. A review on the algal biodiversity by Norton et al. (1996) states that no one knows how many algae actually are there. The community comprises a large number of species and displays minimum characteristics to differentiate (Norton et al., 1996; Andersen, 1992; Uusitalo et al., 2013). Even with the help of the light microscope and electron microscope, expert help is still needed whilst molecular test is of expensive cost besides time consuming (Andersen, 1992). Furthermore, being responsively sensitive to changing environmental parameters makes the phytoplankton individuals spatial and temporally available. Thus, having a list of species which is completely available in a certain water body is hardly possible to be attained at a certain point of time. Nevertheless, to document an inventory of algal flora such as the checklist of algae in Singapore (Pham et al., 2011) in Putrajaya Lake would be a contribution to the algological study in Malaysia.

1.3 Objectives of the study

This study was undertaken with the following objectives;

1. To determine the distribution and biodiversity of phytoplankton in different zonations of Putrajaya Lake.
2. To evaluate the seasonal effects on phytoplankton abundance and biodiversity.
3. To determine the relationship between phytoplankton biodiversity and physical factors.

REFERENCES

Agarkar, D.S., Agarker, M.S. and Dikshit, R. 1979. Desmids from Bandhavgarh, Madhya Pradesh, India. *Hydrobiologia* 65:213-223.

Aik, L.K. 2003. *Studies on the phytoplankton in the lower Bisa area of Putrajaya Lake*. Master Thesis, University of Malaya, Kuala Lumpur.

Alam, M.J., Islam, M.A. and Fulanda, B. 2008. Seasonal variations of phytoplanktonic community structure and production in relation to environmental factors of the southwest coastal waters of Bangladesh. *Journal of Fisheries and Aquatic Science* 3:102-113.

Amanda, K.P. 2004. Man-made Lakes. University of Georgia Press.

Andersen, R.A. 1992. Diversity of eukaryotic algae. *Biodiversity & Conservation* 1:267-292.

Ariyadej, C., Tansakul, R., Tansakul, P. and Angsupanich, S. 2004. Phytoplankton diversity and its relationships to the physico-chemical environment in the Banglang Reservoir, Yala Province. *Songklanakarin Journal of Science and Technology* 26:595-607.

Ashton, P.J. 1985. Seasonality in Southern Hemisphere freshwater phytoplankton assemblages. *Hydrobiologia* 125:179-190.

Băgăcean, D. and Viorel, D. 2014. Natural resources and energy. *Acta Technica Napocensis-Series: Applied Mathematics, Mechanics, and Engineering* 57:215-222.

Barber, H.G. and Haworth, E.Y. 1981. *A guide to the morphology of the diatom frustule: with a key to the British freshwater genera*. Freshwater Biological Association Kendal.

Barbosa, L.G., Barbosa, F.A.R., Araujo, G.J.M. and De M. Bicudo, C.E. 2013. The dominance of desmids in tropical monomictic lakes (SE Brazil). *Limnetica* 32:71-86.

Barton, A.D., Dutkiewicz, S., Flierl, G., Bragg, J. and Follows, M.J. 2010. Patterns of diversity in marine phytoplankton. *Science* 327:1509-1511.

Belcher, J.H. and Swale, E.M.F. 1962. Culture studies on *Ankistrodesmus* and some similar genera: 1. Some less common and new British species. *British Phycological Bulletin* 2:126-132.

Belcher, J.H. and Swale, E.M.F. 1976. *A beginner's guide to freshwater algae*. Her Majesty's Stationery Office.

Belcher, J.H. and Swale, E.M.F. 1978. *A beginner's guide to freshwater algae*. Culture Centre of Algae and Protozoa Cambridge.

Belcher, J.H. and Swale, E.M.F. 1979. *An illustrated guide to river phytoplankton*. Culture Centre of Algae and Protozoa Cambridge.

Bidarulmunir, A., Wan Maznah W.O., Amir Shah Ruddin, M.S., Manisah, T. and Muhammad Adlan, A.H. 2012. Distribution of desmids and dinoflagellates in littoral zones of Pedu Reservoir, Kedah Darul Aman. Universiti Sains Malaysia, Pulau Pinang.

Biswas, S. and Nweze, N. 1990. Phytoplankton of Ogelube Lake, Opi, Anambra State, Nigeria. *Hydrobiologia* 199:81-86.

Bock, C., Luo, W., Kusber, W.-H., Hegewald, E., Pažoutová, M. and Krienitz, L. 2013. Classification of crucigenoid algae: phylogenetic position of the reinstated genus *Lemmermannia*, *Tetrastrum* spp. *Crucigenia tetrapedia*, and *C. lauterbornii* (Trebouxiophyceae, Chlorophyta)[1]. *Journal of Phycology* 49:329-339.

Boyd, C.E. 2000. *Water quality: An introduction*. Springer.

Brook, A. 1982. Desmids of the *Staurastrum tetracerum* group from a eutrophic lake in mid-wales. *British Phycological Journal* 17:259-274.

Brook, A.J. 1981. *The biology of desmids*. University of California Press.

Cairns, J. 1956. Effects of increased temperatures on aquatic organisms. *Ind. Wastes* 1:150-153.

Calijuri, M.C., Dos Santos, A.C.A. and Jati, S. 2002. Temporal changes in the phytoplankton community structure in a tropical and eutrophic reservoir (Barra Bonita, S.P.-Brazil). *Journal of Plankton Research* 24:617-634.

Can, R.B., Sundby, B., Gobeil, C., Silverberg, N. and Mucc, A. 1994. Thermal structure of lakes varying in size and water clarity. *Limnology and Oceanography* 39:968-976.

Carter, N. 1923. *A monograph of the British Desmidiaceae*. London: The Ray Society.

Chakraborty, P., Acharyya, T., Babu, P.R. and Bandyopadhyay, D. 2011. Impact of salinity and pH on phytoplankton communities in a tropical freshwater system: An investigation with pigment analysis by HPLC. *Journal of Environmental Monitoring* 13:614-620.

Clarke, K.R. and Gorley, R.N. 2006. *V6: user manual/tutorial*. Primer-E Ltd. Plymouth.

Clarke, K.R. and Warwick, R.M. 1994. *Change in marine communities: an approach to statistical analysis and interpretation*. Natural Environment Research Council, Plymouth, UK.

Coesel, P.F.M. 1975. The relevance of desmids in the biological typology and evaluation of fresh waters. *Hydrobiological Bulletin* 9:93-101.

Coesel, P.F.M. 1982. Structural Characteristics and Adaptations of Desmid Communities. *Journal of Ecology* 70:163-177.

Coesel, P.F.M. 1993. Poor physiological adaptation to alkaline culture conditions in *Closterium acutum* var. variabile, a planktonic desmid from eutrophic waters. *European Journal of Phycology* 28:53-57.

Coesel, P.F.M. 2000. Desmids (Chlorophyta, Desmidiaceae) from Thale Noi (Thailand). *Nordic Journal of Botany* 20:369–383.

Coesel, P.F.M. and Kooijman-Van Blokland, H. 1994. Distribution and seasonality of desmids in the Maarsseveen Lakes area. *Netherlands Journal of Aquatic Ecology* 28:19-24.

Coesel, P.F.M. and Wardenaar, K. 1990. Growth responses of planktonic desmid species in a temperature-light gradient. *Freshwater biology* 23:551-560.

Cole, G.A. 1979. *Textbook of limnology*. St. Louis. Toronto. London: C. V. Mosby Company.

Connell, J.H. 1978. Diversity in Tropical Rain Forests and Coral Reefs. *Science* 199:1302-1310.

De Senerpont Domis, L.N., Elser, J.J., Gsell, A.S., Huszar, V.L.M., Ibelings, B.W., Jeppesen, E., Kosten, S., Mooij, W.M., Roland, F., Sommer, U., Van Donk, E., Winder, M. and Lürling, M. 2013. Plankton dynamics under different climatic conditions in space and time. *Freshwater Biology* 58:463-482.

Dokulil, M. 1973. Planktonic primary production within the Phragmites community of Lake Neusiedlersee (Austria). *Polskie Archiwum Hydrobiologii* 20: 175-180.

Dokulil, M. 1988. Seasonal and spatial distribution of cryptophycean species in the deep, stratifying, alpine lake Mondsee and their role in the food web. *Hydrobiologia* 161:185-201.

Dokulil, M.T., Markert, B.A., Breure, A.M. and Zechmeister, H.G. 2003. Algae as ecological bio-indicators. In: *Trace Metals and other Contaminants in the Environment*, pp. 285-327. Elsevier.

Echenique, R.O., Núñez-Avellaneda, M. and Duque, S.R. 2004. Chlorococcales de la Amazonia colombiana I: Chlorellaceae y Scenedesmaceae. *Caldasia* 26:37-51.

Echenique, R.O., Núñez-Avellaneda, M. and Duque, S.R. 2013. Chlorococcales de la Amazonia II. *Boletín de la Sociedad Argentina de Botánica* 48, 407-420.

Falkowski, P.G. and Raven, J.A. 2013. *Aquatic photosynthesis*. Princeton University Press.

Fee, E.J., Hecky, R.E., Kasian, S.E.M. and Cruikshank, D.R. 1996. Effects of lake size, water clarity, nd climatic variability on mixing depths in Canadian Shield Lakes. *Limnology and. Oceanography* 41:912-920.

Fenchel, T. and Finlay, B.J. 2004. The ubiquity of small species: patterns of local and global diversity. *Bioscience* 54:777-784.

Fernández, C. and Parodi, E.R. 2005. Chlorococcales nuevas para el embalse Paso de las Piedras (Buenos Aires, Argentina). *Boletín de la Sociedad Argentina de Botánica* 40, 199-205.

Figueredo, C. and Giani, A. 2001. Seasonal variation in the diversity and species richness of phytoplankton in a tropical eutrophic reservoir. *Hydrobiologia* 445:165-174.

Findlay, D. and Kling, H. 1998. Protocols for measuring biodiversity: Phytoplankton in Freshwater. Ecological Monitoring and Assessment Network (EMAN). Department of Fisheries and Oceans, Freshwater Institute, Environment Canada.

Franklin, R., Mills, A., Pinel-Alloul, B. and Ghadouani, A. 2007. Spatial heterogeneity of planktonic microorganisms in aquatic systems. In: The spatial distribution of microbes in the environment. *Springer Netherlands*, pp. 203-310.

Furtado, J.I. and Mori, S. 1982. *Tasek Bera: the ecology of a freshwater swamp*. Dr. W. Junk Publishers.

George, D. and Edwards, R. 1976. The effect of wind on the distribution of chlorophyll a and crustacean plankton in a shallow eutrophic reservoir. *Journal of Applied Ecology* 13:667-690.

George, D.G. and Heaney, S.I. 1978. Factors influencing the spatial distribution of phytoplankton in a small productive lake. *Journal of Ecology* 66:133-155.

Gervais, F.1998. Ecology of cryptophytes coexisting near a freshwater chemocline. *Freshwater Biology* 39: 61–78.

Gervais, F., Siedel, U., Heilmann, B., Weithoff, G., Heisig-Gunkel, G. and Nicklisch, A. 2003. Small-scale vertical distribution of phytoplankton, nutrients and sulphide below the oxycline of a mesotrophic lake. *Journal of Plankton Research* 25:273-278.

Ghosh, S., Barinova, S. and Keshri, J.P. 2012. Diversity and seasonal variation of phytoplankton community in the Santragachi Lake, West Bengal, India. *QScience Connect* 3:1-19.

Gopinathan, C., Rajagopalan, M., Kaladharan, P. and Prema, D. 2007. *Training manual on phytoplankton identification/taxonomy*. Fishery Environment Management Division. Central Marine Fisheries Research Institute.

Goulder, R. 1969. Interactions between the rates of production of a freshwater macrophyte and phytoplankton in a pond. *Oikos* 20:300-309.

Guiry, M.D. 2013. Taxonomy and nomenclature of the Conjugatophyceae (= Zygnematophyceae). *Algae. An Intern. J. Algal Res* 28:1-29.

Guiry, M.D. and Guiry, G.M. 2013. AlgaeBase. In: World-wide electronic publication, National University of Ireland, Galway. http://www.algaebase.org.

Harris, G. 1986. *Phytoplankton ecology: structure, function and fluctuation*. Champman and Hall, London.

Heaney, S.I. 1976. Temporal and spatial distribution of the dinoflagellate *Ceratium hirundinella* O.F. Müller within a small productive lake. *Freshwater biology* 6:531-542.

Heaney, S.I. and Talling, J.F. 1980. Dynamic aspects of dinoflagellate distribution patterns in a small, productive lake. *Journal of Ecology* 68:75-94.

Heino, J., Virkkala, R. and Toivonen, H. 2009. Climate change and freshwater biodiversity: detected patterns, future trends and adaptations in northern regions. *Biological Reviews* 84:39-54.

Hijjas Kasturi Associates Sdn, Pelorus Services Sdn. Bhd and Burchill Partners PTY Limited, *Putrajaya Lake use and navigation master plan and lake and wetland emergency response plan* - Final report for Perbadanan Putrajaya: 2001.

Hillebrand, H. 2004. On the Generality of the Latitudinal Diversity Gradient. *The American Naturalist* 163:192-211.

Hirano, M. 1967. Freshwater algae collected by the joint Thai–Japanese biology expedition to Southeast Asia 1961–1962. In *Nature and life in Southeast Asia, vol V,* eds. T. Kira, and K. Iwata, pp. 1–71. Fauna and Flora Research Society, Kyoto, Japan,

Hirano, M. 1975. Phytoplankton from Lake Boraphet in the central plain of Thailand. Contributions from the Biological Laboratory, Kyoto University 4:187–203.

Hirano, M. 1992. *Desmids from Thailand and Malaysia*. Contributions from the Biological Laboratory, Kyoto University 28:1-98.

Ho, S.-C. 1976. Periphyton production in a tropical lowland stream polluted by inorganic sediments and organic wastes. *Arch. Hydrobiologia*. 77:458-474.

Ho, S.-C. 1995. Status of limnological research and training in Malaysia. In *Limnology in Developing Countries,* eds B. Gopal and R.G. Wetzel, pp. 163-189. International Association for Limnology. International Scientific Publications.

Hooker, E. and Hernandez, S. 1991. Phytoplankton biomass in Lake Xolotlán (Managua): Its seasonal and horizontal distribution. *Hydrobiological Bulletin* 25:125-131.

Hubble, D. and Harper, D. 2002. Phytoplankton community structure and succession in the water column of Lake Naivasha, Kenya: a shallow tropical lake. *Hydrobiologia* 488:89-98.

Huisman, J. 2010. Comment on "Patterns of diversity in marine phytoplankton". *Science* 329:512-512.

Hunter, D.A., Goldman, C.R. and Byron, E.R. 1990. Changes in the phytoplankton community structure in Lake Tahoe, California-Nevada. *Verhandlungen des Internationalen Verein Limnologie* 24:505-508.

Huszar, V.L.M. and Reynolds, C.S. 1997. Phytoplankton periodicity and sequences of dominance in an Amazonian flood-plain lake (Lago Batata, Pará, Brasil): responses to gradual environmental change. *Hydrobiologia* 346:169-181.

Hutchinson, G.E. 1961. The Paradox of the Plankton. *The American Naturalist* 95:137-145.

Hutchinson, G.E. 1966. *Introduction to Lake Biology and the Limnoplakton*. John Wiley & Sons.

Irfanullah, H. and Moss, B. 2006. Ecology of *Dictyosphaerium pulchellum* Wood (Chlorophyta, Chlorococcales) in a shallow, acid, forest lake. *Aquatic Ecology* 40:1-12.

Islam, A.K.M.N. and Irfanullah, H.M. 2005a. Hydrobiological studies within the tea gardens at Srimangal, Bangladesh. II. Algal flora (excluding Chlorophyceae). *Bangladesh Journal of Plant Taxonomy* 12:33-52.

Islam, A.K.M.N. and Irfanullah, H.M. 2005b. Hydrobiological studies within the tea gardens at Srimangal, Bangladesh. III. Chlorophyceae (excluding desmids). *Bangladesh Journal of Plant Taxonomy* 12:19-37.

Islam, A.K.M.N. and Irfanullah, H.M. 2005c. Hydrobiological studies within the tea gardens at Srimangal, Bangladesh. IV. Desmids (17 genera). *Bangladesh Journal of Plant* Taxonomy 12:49-62.

Islam, A.K.M.N. and Irfanullah, H.M. 2006a. Hydrobiological studies within the tea gardens at Srimangal, Bangladesh. V. Desmids (Euastrum, Micrasterias, Actinotaenium and Cosmarium). *Bangladesh Journal of Plant Taxonomy* 13:1-20.

Islam, A.K.M.N. and Irfanullah, H.M. 2006b. Hydrobiological studies within the tea gardens at Srimangal, Bangladesh. VI. Desmids (Xanthidium, Arthrodesmus, Staurodesmus and Staurastrum*). Bangladesh Journal of Plant Taxonomy* 13:111-129.

Jankowski, T. and Weyhenmeyer, A.G. 2006. The role of spatial scale and area in determining richness-altitude gradients in Swedish lake phytoplankton communities. *Oikos* 115:433-442.

John, D.M., Whitton, B.A. and Brook, A.J. 2002. *The freshwater algal flora of the British Isles: An identification guide to freshwater and terrestrial algae*. Cambridge University Press.

Jones, R., Fulcher, A., Jayakody, J., Laybourn-Parry, J., Shine, A., Walton, M. and Young, J. 1995. The horizontal distribution of plankton in a deep, oligotrophic lake-Loch Ness, Scotland. *Freshwater biology* 33:161-170.

Kalff, J. and Watson. 1986. Phytoplankton and its dynamics in two tropical lakes: a tropical and temperate zone comparison. *Hydrobiologia* 138:161-176.

Kanetsuna, Y. 2002. New and interesting desmids (Zygnematales, Chlorophyceae) collected from Asia. *Phycological Research* 50:101–113.

Karr, J.R. and Chu, E.W. 1999. *Restoring life in running waters: better biological monitoring*. Island Press.

Khuantrairong, T. and Traichaiyaporn, S. 2008. Diversity and seasonal succession of the phytoplankton community in Doi Tao Lake, Chiang Mai Province, Northern Thailand. *The Natural History Journal of Chulalongkorn University* 8:143-156.

Kirk, J.T.O. 1994. *Light and photosynthesis in aquatic ecosystems*. Cambridge university press.

Klausmeier, C.A. and Litchman, E. 2001. Algal games: The vertical distribution of phytoplankton in poorly mixed water columns. *Limnology and Oceanography* 46:1998-2007.

Klaveness, D. 1988. *Ecology of the Cryptomonadida: A first review. Growth and reproductive strategies of freshwater phytoplankton*. Cambridge University Press, Cambridge.

Kruk, C., Mazzeo, N., Lacerot, G. and Reynolds, C.S. 2002. Classification schemes for phytoplankton: a local validation of a functional approach to the analysis of species temporal replacement. *Journal of Plankton Research* 24:901-912.

Kruk, C., Huszar, V.L.M., Peeters, E.T.H.M., Bonilla, S., Costa, L., Lürling, M., Reynolds, C.S., and Scheffer, M. 2010. A morphological classification capturing functional variation in phytoplankton. *Freshwater Biology* 55:614-627

Kutty, A.A., Ismail, A. and Fong, C.S. 2001. A preliminary study of phytoplankton at Lake Chini, Pahang. *Pakistan Journal of Biological Sciences* 4:309-313.

Lampert, W. and Sommer, U. 2007. *Limnoecology: the ecology of lakes and streams*. Oxford University Press.

Legendre, L. and Watt, W. 1971. On a rapid technique for plankton enumeration. *Annales de I'Institut Océanographique (Paris)* 48:173-177.

Leonardson, L. and Ripl, W. 1980. Control of undesirable algae and induction of algal successions in hypertrophic lake ecosystems. In *Hypertrophic ecosystems*, eds. J. Barica, and L. Mur, pp. 57-65. Springer.

Lewis Jr, W.M. 1978a. Analysis of succession in a tropical phytoplankton community and a new measure of succession rate. *American Naturalist* 112:401-414.

Lewis Jr, W.M. 1978b. Dynamics and Succession of the Phytoplankton in a Tropical Lake: Lake Lanao, Philippines. *Journal of Ecology* 66:849-880.

Lewis Jr, W.M. 1978c. A Compositional, Phytogeographical and Elementary Structural Analysis of the Phytoplankton in a Tropical Lake: Lake Lanao, Philippines. *Journal of Ecology* 66:213-226.

Lewis Jr, W.M. 1987. Tropical Limnology. *Annual Review of Ecology and Systematics* 18:159-184.

Lewis Jr, W.M. 1996. Tropical lakes: how latitude makes a difference. *Perspectives in tropical limnology* 43-64.

Lexie. 2014. This Algae Farm Eats Pollution From the Highway Below!, http://thespiritscience.net/2014/11/03/this-algae-farm-eats-pollution-from-the-highway-below/ Accessed 2014 November 11.

Ligęza, S. and Wilk-Woźniak, E. 2011. The occurrence of a *Euglena pascheri* and *Lepocinclis ovum* bloom in an oxbow lake in southern Poland under extreme environmental conditions. *Ecological Indicators* 11:925-929.

Ling, H., Croome, R. and Tyler, P. 1989. Freshwater dinoflagellates of Tasmania, a survey of taxonomy and distribution *British Phycological Journal* 24:111-129.

Litchman, E. 1998. Population and community responses of phytoplankton to fluctuating light. *Oecologia* 117:247-257.

Longhi, M.L. and Beisner, B.E. 2009. Environmental factors controlling the vertical distribution of phytoplankton in lakes. *Journal of Plankton Research* 31:1195-1207.

Lopes, M., M. Bicudo, C. and Carla Ferragut, M. 2005. Short term spatial and temporal variation of phytoplankton in a shallow tropical oligotrophic reservoir, southeast Brazil. In *Aquatic Biodiversity II*, eds. H. Segers, and K. Martens, pp. 235-247. Springer Netherlands.

Lund, J.W.G., Kipling, C. and Cren, E.D. 1958. The inverted microscope method of estimating algal numbers and the statistical basis of estimations by counting. *Hydrobiologia* 11:143-170.

Magurran, A.E. 1988. *Ecological diversity and its measurement*. Springer.

Makhlough, A. 2008. *Water quality characteristics of Mengkuang Reservoir based on phytoplankton community structure and physico-chemical analysis*. Master Thesis, Universiti Sains Malaysia.

Malek, S., Salleh, A. and Baba, M.S. 2009. Prediction of Population Dynamics of Bacillariophyta in the Tropical Putrajaya Lake and Wetlands (Malaysia) by a

Recurrent Artificial Neural Networks. In *Environmental and Computer Science, ICECS '09.* Second International Conference.

Malek, S., Salleh, A., Milow, P., Baba, M.S. and Sharifah, S.A. 2012. Applying artificial neural network theory to exploring diatom abundance at tropical Putrajaya Lake, Malaysia. *Journal of Freshwater Ecology* 27:211-227.

Maria, d.C.B.-O. 1993. Ficoflórula do rio Tibagi, estado do Paraná, Brasil, III: Gêneros *Actinotaenium*, *Cosmarium*, e *Staurodesmus* (Zygnemaphyceae). Semina: *Ciências Biológicas e da Saúde* 14:86-95.

Maznah, W.O. and Mansor, M. 1999. Benthic diatoms in the Pinang River (Malaysia) and its tributaries with emphasis on species diversity and water quality. *International Journal on Algae* 1:103-118.

McCormick, P. and Cairns, J., Jr. 1994. Algae as indicators of environmental change. *Journal of Applied Phycology* 6:509-526.

Melack, J.M. 1979. Temporal variability of phytoplankton in tropical lakes. *Oecologia* 44:1-7.

Merican, F., Wan Asmadi, W., Omar, W.M.W. and Mashhor, M. 2006. A note on the freshwater algae of Gunung Stong, Kelantan, Malaysia. *Jurnal Biosains* 17:65-76.

Mizuno, T. 1978. *Illustrations of the freshwater plankton of Japan*. Hoikusha Publishing Co. Ltd.

Moss, B. 1973. The influence of environmental factors on the distribution of freshwater algae: an experimental study: II. The role of pH and the carbon dioxide-bicarbonate system. *Journal of Ecology* 61:157-177.

Nabout, J.C., Nogueira, I.S. and Oliveira, L.G. 2006. Phytoplankton community of floodplain lakes of the Araguaia River, Brazil, in the rainy and dry seasons. *Journal of Plankton Research* 28:181-193.

National Hydraulic Research Institute of Malaysia (NAHRIM), A desktop study on the status of lake eutrophication in Malaysia 2005. Final report, August 2005.

Naselli-Flores, L. 1999. Limnological aspects of Sicilian reservoirs: a comparative ecosystemic approach. *Theoretical Reservoir Ecology and its Applications*. Backhuys Publishers, Leiden: 283-311.

Naselli-Flores, L. and Barone, R. 1998. Phytoplankton dynamics in two reservoirs with different trophic state (Lake Rosamarina and Lake Arancio, Sicily, Italy). *Hydrobiologia* 369-370:163-178.

Naselli-Flores, L. and Barone, R. 2000. Phytoplankton dynamics and structure: a comparative analysis in natural and man-made water bodies of different trophic state. *Hydrobiologia* 438:65-74.

Naselli-Flores, L., Padisák, J., Dokulil, M.T. and Chorus, I. 2003. Equilibrium/steady-state concept in phytoplankton ecology. *Hydrobiologia* 502:395-403.

Nather Khan I.S.A. 1990. Assessment of water pollution using diatom community structure and species distribution: A case study in a tropical river basin. *Internationae Revue der gesamten Hydrobiologie and Hydrographie* 75: 317–338.

Nather Khan I.S.A. 1991. Effect of urban and industrial wastes on species diversity of the diatom community in a tropical river, Malaysia. *Hydrobiologia* 224: 175–184.

Nather Khan I.S.A. 1985. *Studies on the water quality and periphyton community in Linggi River Basin, Malaysia*. PhD Thesis, University Malaya.

National Hydraulic Research Institute of Malaysia (NAHRIM), *A desktop study on the status of lake eutrophication in Malaysia* - Final report. 2005.

Ndebele-Murisa, M.R., Musil, C.F. and Raitt, L. 2010. A review of phytoplankton dynamics in tropical African lakes. *South African Journal of Science* 106:13-18.

Ngearnpat, N. and Peerapornpisal, Y. 2007. Application of desmid diversity in assessing the water quality of 12 freshwater resources in Thailand. *Journal of Applied Phycology* 19:667-674.

Norizam, M.M. and Ali, A. 2000. A comparative study on the secondary productivity of the littoral and limnetic zone of Temenggor Reservoir, Perak, Malaysia. *Journal of Bioscience* 1 & 2:1-10.

Norton, T.A., Melkonian, M. and Andersen, R.A. 1996. Algal biodiversity*. *Phycologia* 35:308-326.

Omar, W.M.W. 2010. Perspectives on the use of algae as biological indicators for monitoring and protecting aquatic environments, with special reference to Malaysian freshwater ecosystems. *Tropical life sciences research* 21:51-67.

Padisák, J., Crossetti, L. and Naselli-Flores, L. 2009. Use and misuse in the application of the phytoplankton functional classification: a critical review with updates. *Hydrobiologia* 621:1-19.

Padisák, J., Hajnal, É., Naselli-Flores, L., Dokulil, M., Nõges, P. and Zohary, T. 2010. Convergence and divergence in organization of phytoplankton communities under various regimes of physical and biological control. *Hydrobiologia* 639:205-220.

Pal, R. and Choudhury, A. 2014. Case Study. In: An Introduction to Phytoplanktons: Diversity and Ecology. *Springer India*, pp. 75-161.

Pallant, J. 2007. *SPSS survival manual: a step by step guide to data analysis using SPSS*. England: McGraw-Hill.

Palmer, C.M. 1959. *Algae in water supplies: an illustrated manual on the identification, significance, and control of algae in water supplies*. Cincinnati: U.S. deptartment of health, education, and welfare, public health service.

Pasztaleniec, A. and Poniewozik, M. 2004. *Pediastrum* species (Hydrodictyaceae, Sphaeropleales) in phytoplankton of Sumin Lake (Łęczna-Włodawa Lakeland). *Acta Societatis Botanicorum Poloniae* 73:39-46.

Pasztaleniec, A., Karpowicz, M. and Strzałek, M. 2013. The influence of habitat conditions on the plankton in the Białe oxbow lake (Nadbużański Landscape Park). *Limnological Review* 13:3-59.

Patrick, R. 1936. A taxonomic and distributional study of some diatoms from Siam and the Federated Malay States. *Proceedings of the Academy of Natural Sciences of Philadelphia* 88:367-470.

Perez, M.-C., Comas, A., Del, R. A. and Sierra, J. 2002. Planktonic Chlorophyceae from the lower Ebro River (Spain). *Acta Botanica Croatica* 61:99-124.

Pham, M.N., Tan, H.T., Mitrovic, S. and Yeo, H.H. 2011. A checklist of the algae of Singapore. Singpore: Raffles Museum of Biodiversity Research, National University of Singapore, 1-100.

Pinilla, G. 2006. Vertical distribution of phytoplankton in a clear water lake of Colombian Amazon (Lake Boa, Middle Caquetá). *Hydrobiologia* 568:79-90.

Pongswat, S. 2002. The use of phytoplankton biodiversity for monitoring water quality in Rama IX Lake, Pathumthani Province, PhD Thesis, Suranaree University of Technology.

Post, W.M., Peng, T.-H., Emanuel, W.R., King, A.W., Dale, V.H. and DeAngelis, D.L. 1990. The global carbon cycle. *American scientist* 78:310-326.

Pröschold, T. and Leliaert, F. 2007. 7 Systematics of the green algae: conflict of classic and modern approaches. In: *Unravelling the algae: the past, present, and future of algal systematics*, pp. 123-153.

Prowse, G.A. 1957. An introduction to the desmids of Malaya. *Malayan Nature Journal* 11:42-58.

Prowse G.A. 1958. The Eugleninae of Malaya. *Gard Bull Singapore* 16:136-204.

Prowse, G. 1960. New and unusual flagellata in Malaya. *In: Proceedings: University of Malaya Press*: pp. 292.

Prowse, G.A. 1962. *Diatoms of Malayan freshwaters*. Botanic Gardens.

Ptacnik, R., Diehl, S. and Berger, S. 2003. Performance of sinking and nonsinking phytoplankton taxa in a gradient of mixing depths. *Limnology and Oceanography* 48:1903-1912.

Rai, U.N., Dwivedi, S., Baghel, V.S., Tripathi, R.D., Shukla, O.P. and Shukla, M.K. 2007. Morphology and cultural behavior of *Botryococcus protuberans* with notes on the genus. *Journal of Environmental Biology* 28:181-184.

Ramos, G.J.P., Bicudo, C.E.d.M., Góes Neto, A. and Moura, C.W.d.N. 2012. *Monoraphidium* and *Ankistrodesmus* (Chlorophyceae, Chlorophyta) from Pantanal dos Marimbus, Chapada Diamantina, Bahia State, Brazil. *Hoehnea* 39:421-434.

Reynolds, C.S. 1972. Growth, gas vacuolation and buoyancy in a natural population of a planktonic blue-green alga. *Freshwater biology* 2:87-106.

Reynolds, C.S. 1984. Phytoplankton periodicity: the interactions of form, function and environmental variability. *Freshwater biology* 14:111-142.

Reynolds, C.S. 1999. Phytoplankton assemblages in reservoirs. In *Theoretical reservoir ecology and its applications*, eds. J.G. Tundisi, and M. Straškaba, pp. 439-456. Backhuys Publishers, São Paulo.

Reynolds, C.S. 2006. *The ecology of freshwater phytoplankton*. Cambridge University Press.

Reynolds, C.S., Huszar, V., Kruk, C., Naselli-Flores, L. and Melo, S. 2002. Towards a functional classification of the freshwater phytoplankton. *Journal of plankton research* 24:417-428.

Rosas, I., Velasco, A., Belmont, R., Baez, A. and Martinez, A. 1993. The algal community as an indicator of the trophic status of Lake Patzcuaro, Mexico. *Environmental Pollution* 80:255-264.

Ryan, N., Mitrovic, S. and Bowling, L. 2008. Temporal and spatial variability in the phytoplankton community of Myall Lakes, Australia, and influences of salinity. *Hydrobiologia* 608:69-86.

Salleh, A. 1996. *Panduan mengenali alga air tawar*. Dewan Bahasa dan Pustaka, Kuala Lumpur.

Salmaso, N. and Padisák, J. 2007. Morpho-functional groups and phytoplankton development in two deep lakes (Lake Garda, Italy and Lake Stechlin, Germany). *Hydrobiologia* 578:97-112.

Sánchez, E., Colmenarejo, M. F., Vicente, J., Rubio, A., Garcia, M. G., Travieso, L. and Borja, R. 2007. Use of the water quality index and dissolved oxygen deficit as simple indicators of watersheds pollution. *Ecological Indicators* 7:315–328.

Sandulli, R. and Pinckney, J. 1999. Patch sizes and spatial patterns of meiobenthic copepods and benthic microalgae in sandy sediments: a microscale approach. *Journal of Sea Research* 41:179-187.

Scheffer, M. 2004. *Ecology of shallow lakes*. Springer.

Scott, A.M. and Prescott, G.W. 1961. Indonesian desmids. *Hydrobiologia* 17:1-132.

Shamsudin, L. 1991. *Diatom Air Tawar: Morfologi dan Taksonomi*. Dewan Bahasa dan Pustaka, Kementerian Pendidikan Malaysia, Kuala Lumpur.

Sharma, B. 1995. Limnological studies in a small reservoir in Meghalaya (NE India). *Tropical limnology* 2:187-197.

Shiel, R.J. and Williams, W.D. 1990. Species richness in tropical fresh waters of Australia. *Hydrobiologia* 202:175-183.

Shirota, A. 1966. *The plankton of South Viet-nam*. Fresh Water and Marine Plankton. Overseas Technical Cooperation Agency Japan.

Silva, S.R.V.F., and Cecy, I.Ĺ.T. 2004. Desmídias (Zygnemaphyceae) da área de abrangência da Usina Hidrelétrica de Salto Caxias, Paraná, Brasil, I: Gênero *Cosmarium*. *Iheringia, série Botânica* 59:13-26.

Sommer, U., Gliwicz, Z.M., Lampert, W. and Duncan, A. 1986. PEG-model of seasonal succession of planktonic events in fresh waters. *Archiv fuer Hydrobiologie* 106:433-471

Sommer, U., Padisák, J., Reynolds, C.S. and Juhász-Nagy, P. 1993. Hutchinson's heritage: the diversity-disturbance relationship in phytoplankton. *Hydrobiologia* 249:1-7.

Sorayya, M., Aishah, S. and Sapiyan, B.M. 2012. Supervised and unsupervised artificial neural networks for analysis of diatom abundance in tropical Putrajaya Lake, Malaysia. *Sains Malaysiana* 41:939-947.

Stevenson, R.J., Smol, J.P., John, D.W. and Robert, G.S. 2003. Use of Algae in Environmental Assessments. In *Freshwater Algae of North America Burlington,* pp. 775-804. Academic Press.

Stomp, M., Huisman, J., de Jongh, F., Veraart, A.J., Gerla, D., Rijkeboer, M., Ibelings, B.W., Wollenzien, U.I. and Stal, L.J. 2004. Adaptive divergence in pigment composition promotes phytoplankton biodiversity. *Nature* 432:104-107.

Stomp, M., Huisman, J., Mittelbach, G.G., Litchman, E. and Klausmeier, C.A. 2011. Large-scale biodiversity patterns in freshwater phytoplankton. *Ecology* 92:2096-2107.

Taft, C.E. 1945. The desmids of the west end of Lake Erie. *Ohio Journal of Science* 45:180-205.

Talling, J.F. 1986. The seasonality of phytoplankton in African lakes. *Hydrobiologia* 138:139-160.

Tavera, R. and Victor, M.-A. 2005. Atelomixis as a possible driving force in the phytoplankton composition of Zirahuén, a warm-monomictic tropical lake. *Hydrobiologia* 533:199-208.

Taylor, F.J.R. and Pollingher, U. 1987. *Ecology of dinoflagellates. The biology of dinoflagellates*. Blackwell Scientific Oxford.

Taylor, F.J.R., Hoppenrath, M. and Saldarriaga, J.F. 2008. Dinoflagellate diversity and distribution. *Biodiversity and Conservation* 17:407-418.

Thienemann, A. 1954. Tropical freshwater plankton. In *Symposium on marine and fresh water plankton in the Indo-Pacific, Bangkok*, pp. 85-59.

Thompson, R.H. 1959. Algae. In *Fresh-Water Biology*, ed. W.T. Edmondson, pp. 115-189. Wiley.

Tilman, D., Kilham, S.S. and Kilham, P. 1982. Phytoplankton community ecology: the role of limiting nutrients. *Annual Review of Ecology and Systematics* 13:349-372.

Uusitalo, L., Fleming-Lehtinen, V., Hällfors, H., Jaanus, A., Hällfors, S. and London, L. 2013. A novel approach for estimating phytoplankton biodiversity. *ICES Journal of Marine Science: Journal du Conseil* 70:408-417.

Vyverman, W. 1996. 11. The Indo-Malaysian North-Australian phycogeographical region revised. *Hydrobiologia* 336:107-120.

Wehr, J.D. 2002. *Freshwater algae of North America: ecology and classification*. Academic Press.

Wehr, J.D. and Sheath, R.G. 2003. *Freshwater algae of North America: Ecology and classification*. Academic Press.

West, W. and West, G.S. 1912. *A monograph of the British Desmidiaceae*. London: The Ray Society.

West, W., and West, G.S. 1904. *A monograph of the British Desmidiaceae*. London: The Ray Society.

West, W., and West, G.S. 1905. *A monograph of the British Desmidiaceae*. London: The Ray Society.

West, W., and West, G.S. 1908. *A monograph of the British Desmidiaceae*. London: The Ray Society.

Wetzel, R. G. and Likens, G. 1991. *Limnological analysis*. Springer Verlag, New York.

Wetzel, R.G. 2001. *Limnology: lake and river ecosystems*. Academic press.

Willén, E. and Willén, T. 1978. About freshwater phytoplankton. In *Pytoplankton manual. monographs on oceanographic methodology*, ed. A. Sournia. Paris: UNESCO.

Woelkerling, W. and Gough, S. 1976. Wisconsin desmids. III. Desmid community composition and distribution in relation to lake type and water chemistry. *Hydrobiologia* 51:3-31.

Wong, C.L., Venneker, R., Uhlenbrook, S., Jamil, A.B.M. and Zhou, Y. 2009. Variability of rainfall in Peninsular Malaysia. *Hydrology and Earth System Sciences Discussions* 6:5471-5503.

Wynne, B.H. and Bold, H. 1985. *Introduction to the algae. Structure and reproduction*. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, USA.

Yamagishi, T. and Kanetsuna, Y. 1987. The planktonic Chlorophyceae from Lake Boraphet (The Central Plain, Thailand). *General Education Review College Agricultur & Veterinary Medicine Nihon* 23:19–38.

Yap S.Y. 1997. Classification of a Malaysian river using biological indices: A preliminary attempt. *The Environmentalist* 17: 79–86.

Yeng C.K. 2006. *A study on limnology and phytoplankton biodiversity of Ahning Reservoir, Kedah*. Master Thesis., Universiti Sains Malaysia.

Yusoff, F.M. and Lock, M.A. 1994. Thermal stratification and its role in controlling eutrophication in a tropical reservoir, Malaysia. In *Tropical Limnology* Vol. II, eds. K.H. Timotius, and F. Goltenboth, pp. 277-285. Satya Wacana Christian University, Salatiga, Indonesia.

Yusoff, F.M. and McNabb, C.D. 1989. Effects of nutrient availability on primary productivity and fish production in fertilized tropical ponds. *Aquaculture* 78:303-319.

Yusoff, F.M. and McNabb, C.D. 1997. The effects of phosphorus and nitrogen on phytoplankton dominance in tropical fish ponds. *Aquaculture Research* 28:591-597.

Yusoff, F.M. and Patimah, I. 1994. A comparative study of phytoplankton populations in two Malaysian lakes. *International Association of Theoretical and Applied Limnology* 24:251-257.

Yusoff, F.M., Happey-Wood, C.M. and Anton, A. 1998. Vertical and seasonal distribution of phytoplankton in a tropical reservoir, Malaysia. *International Review of Hydrobiology* 83:121-134.

Yusoff, F.M., Mohsin, M., Khair, A., Satar, A. and Kamal, M. 1984. Phytoplankton composition and productivity of a shallow tropical lake. *Pertanika* 7:101-113.

Zohary, T., Padisák, J. and Naselli-Flores, L. 2010. Phytoplankton in the physical environment: beyond nutrients, at the end, there is some light. *Hydrobiologia* 639: 261-269.

Zulkifli A. M. 1980. *Biological productivity in Muda and Pedu Reservoir, and canal system*. Pulau Pinang, Malaysia: Universiti Sains Malaysia.

LIST OF PUBLICATIONS

Jamal, A., Yusoff, F. M., Sharif, M. and Banerjee, S. 2014. Littoral and Limnetic Phytoplankton Distribution and Biodiversity in a Tropical Man-made Lake, Malaysia. *Advanced Studies in Biology*. 6:149-168.

Jamal, A., Yusoff, F. M. and Srikanth, R. M. 2015. Growth rate assessment of high lipid producing microalga Botryococcus braunii in different culture media. *Iranian Journal of Fisheries Sciences.* 14.2: 436-445.

UNIVERSITI PUTRA MALAYSIA

STATUS CONFIRMATION FOR THESIS / PROJECT REPORT AND COPYRIGHT

ACADEMIC SESSION : ____________________

TITLE OF THESIS / PROJECT REPORT :

DISTRIBUTION AND DIVERSITY OF PHYTOPLANKTON IN A TROPICAL MAN-MADE LAKE, PUTRAJAYA, MALAYSIA

NAME OF STUDENT: ASMA' BINTI JAMAL

I acknowledge that the copyright and other intellectual property in the thesis/project report belonged to Universiti Putra Malaysia and I agree to allow this thesis/project report to be placed at the library under the following terms:

1. This thesis/project report is the property of Universiti Putra Malaysia.
2. The library of Universiti Putra Malaysia has the right to make copies for educational purposes only.
3. The library of Universiti Putra Malaysia is allowed to make copies of this thesis for academic exchange.

I declare that this thesis is classified as :

*Please tick (√)

☐	**CONFIDENTIAL**	(Contain confidential information under Official Secret Act 1972).
☐	**RESTRICTED**	(Contains restricted information as specified by the organization/institution where research was done).
☐	**OPEN ACCESS**	I agree that my thesis/project report to be published as hard copy or online open access.

This thesis is submitted for :

☐	**PATENT**	Embargo from ____________ (date) until ____________ (date)

Approved by:

(Signature of Student)	(Signature of Chairman of Supervisory Committee)
New IC No/ Passport No.:	Name:
Date :	Date :

[Note : If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organization/institution with period and reasons for confidentially or restricted.]