UNIVERSITI MALAYSIA SARAWAK
UNIMAS

Faculty of Resource Science and Technology

COMPOSITION AND CHLOROPHYLL *a* OF PHYTOPLANKTON IN UNIMAS LAKES, KOTA SAMARAHAN, SARAWAK

Tan Kian Leong

Bachelor of Science with Honours
(Aquatic Resource Science and Management)
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UNIVERSITI MALAYSIA SARAWAK

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Final Year Project Report ☐

Masters ☐

PhD ☐

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COMPOSITION AND CHLOROPHYLL *a* OF PHYTOPLANKTON IN UNIMAS LAKES, KOTA SAMARAHAN, SARAWAK

TAN KIAN LEONG

This project is submitted in partial fulfillment of the requirements for the degree of

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Tan Kian Leong

Aquatic Resource Science and Management Programme

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Universiti Malaysia Sarawak

TABLE OF CONTENTS

LIST OF ABBREVIATION

Abbreviation	Description
µm	Micrometre
mL	Millilitre
mm	Millimetre
SiO_2	Silica
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
CO_2	Carbon Dioxide
NO_3^--N	Nitrate
PO_4^{3-}	Orthophosphate
H_2O_2	Hydrogen Peroxide
HCl	Hydrogen Chloride
$MgCO_3$	Magnesium Carbonate
rpm	Revolutions per minute
GPS	Global Positioning System
ANOVA	Analysis of Variance

LIST OF TABLES

LIST OF FIGURES

Composition and Chlorophyll *a* of Phytoplankton in UNIMAS Lakes, Kota Samarahan, Sarawak

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ABSTRACT

The composition and chlorophyll *a* of phytoplankton was studied along with physico-chemical parameters of water in the man-made lakes of Universiti Malaysia Sarawak (UNIMAS), Kota Samarahan i.e., West Campus Lake (WC), East Campus Lake 1 (EC1) and East Campus Lake 2 (EC2). Sampling of phytoplankton was conducted in November 2014 and February 2015. A total of 17 genera of phytoplankton were recorded from these lakes in November 2014 comprising 6 taxa of Chlorophyceae; 6 taxa of Bacillariophyceae; 1 taxon of Dinophyceae; 2 taxa of Cyanophyceae and 2 taxa of Euglenophyceae. In February 2015, a total of 18 genera of phytoplankton were also recorded from these lakes. Among the 18 genera, 6 taxa were from Chlorophyceae; 7 taxa were from Bacillariophyceae; 1 taxon was from Cyanophyceae; 1 taxon was from Dinophyceae and 3 taxa were from Euglenophyceae. Chlorophyceae was found to be the dominant group of phytoplankton in the UNIMAS Lakes. Pearson correlation coefficient revealed that chlorophyll *a* was negatively correlated with dissolved oxygen (DO) and orthophosphate (PO_4^{3-}). Comparison was made between the physico-chemical parameters of the water in UNIMAS lakes with other lakes in Malaysia such as Putrajaya Lake and Temenggor Lake.

Key words: Phytoplankton, biomass, composition, physico-chemical parameter, man-made lake

ABSTRAK

Kajian mengenai komposisi dan klorofil a fitoplankton telah dianalisis bersama-sama dengan parameter fiziko-kimia air di tasik buatan manusia Universiti Malaysia Sarawak (UNIMAS), Kota Samarahan iaitu, Tasik Kampus Barat (KB), Tasik Kampus Timur 1 (KT1) dan Tasik Kampus Timur 2 (KT2). Persampelan fitoplankton telah dijalankan dalam bulan November 2014 dan Februari 2015. Sebanyak 17 genus fitoplankton telah direkodkan dari ketiga-tiga tasik ini pada bulan November 2014 yang terdiri daripada 6 taksa daripada Chlorophyceae; 6 taksa daripda Bacillariophyceae; 1 takson daripada Dinophyceae; 2 taksa daripada Cyanophyceae dan 2 taksa daripada Eugleonphyceae. Pada bulan Februari 2015, sejumlah 18 genus fitoplankton juga telah direkodkan dari tasik tersebut. Antara 18 genus, 6 taksa adalah daripada Chlorophyceae; 7 taksa adalah daripada Bacillariophyceae; 1 takson adalah daripada Cyanophyceae; 1 takson adalah daripada Dinophyceae dan 3 taksa adalah daripada Euglenophyceae. Chlorophyceae didapati merupakan kumpulan fitoplankton yang dominan di Tasik UNIMAS. Pekali korelasi Pearson menunjukkan bahawa klorofil a mempunyai hubungan yang negatif dengan oksigen terlarut dan ortofosfat (PO_4^{3-}). Perbandingan telah dibuat antara parameter fiziko-kimia air di dalam tasik UNIMAS dengan tasik lain di Malaysia seperti Tasik Putrajaya dan Tasik Temenggor.

Kata kunci*: Fitoplankton, biojisim, komposisi, parameter fiziko-kimia, tasik buatan manusia*

1.0 Introduction

Variation in phytoplankton biomass and composition has been found between lakes of different trophic status (Negro et al., 2000). According to Negro et al. (2000), high volume of biomass can be found in the lakes which are rich in nutrients compared to those lakes which are poor in nutrients. Physico-chemical parameters and nutrients concentration in the water can influence the abundance and distribution of phytoplankton (Saifullah et al., 2014).

Payne (1986) stated that formation of lake basins are triggered by the various geological events such as volcanic activities, tectonic plate movement of the Earth's crust or formation of glaciers. A lake can be divided into several zones which are pelagic zone, profundal zone and littoral zone. Lake is usually described as lentic which means that the water is non-flowing. The water in lakes originates from the rain falling on the surface of the lakes, groundwater seepage or inflow of streams and river (Payer, 1986).

The UNIMAS Lakes is a type of man-made lakes. A study conducted by Shamsu (2005) found that there are various sewages entering the lakes such as food waste, human faeces and chemical waste discharge from the Medical and Resource Science laboratories. These sewages will provide nutrients for the phytoplankton in the lakes. It became the primary source for the phytoplankton's growth and fertility.

Phytoplankton are characterized as single-celled algae that capable to produce their own food through photosynthesis. They can be found over a wide range of sizes, from photosynthetic bacteria to large diatoms chains and dinofloagellates. According to Morris (1980), phytoplankton is constituted of unicellular algae including diatoms and dinoflagellates. Diatoms and dinoflagellates made up 40% of the phytoplankton in the world and contributed about 20-25% of the net primary productivity (Sushanth & Rajashekhar, 2012).

Kowalska and Wolowski (2010) observed that chlorophyceae are the most common green algae that widely distributed in all freshwater ecosystem. They may occur as unicellular, colonial or filamentous. They are the mostly closely related species to higher plants because of their storage of starch, and structural arrangement of chloroplast as well as contain the similar chlorophyll *a*, *b* and carotene (Koffi et al., 2010).

Although various phytoplankton studies have been conducted in Malaysia, there are limited phytoplankton studies in details especially on phytoplankton composition and their correlation with physico-chemical parameters (e.g., pH, dissolved oxygen, temperature, turbidity, nitrate, phosphate and chlorophyll *a*) in tropical countries. In Malaysia, the studies are mostly on phytoplankton assemblages, productivity and its genetic diversity, such as in the coastal waters of Manjung, Perak (Muhammad Adlan et al., 2012), mangrove estuaries of Kuala Sibuti and Kuala Nyalau, Sarawak (Saifullah et al., 2014), Lake Chini, Pahang (Kutty et al., 2001), Paya Bungor, Pahang (Fatimah et al., 1984) and Kota Samarahan, Sarawak (Fizawati, 2012). There was lack of information being collected on the phytoplankton composition and its chlorophyll *a* in Sarawak especially in the lakes of UNIMAS West Campus and East Campus. Therefore, a study had been conducted **1)** to document the generic composition of phytoplankton in UNIMAS lakes and **2)** to relate the chlorophyll *a* with the physico-chemical parameters of the water in the lakes.

2.0 Literature Review

Phytoplankton comprise of both eukaryotic and prokaryotic organisms. Both of this organisms contain chlorophyll which could act as an indication of phytoplankton biomass and useful in the pelagic studies (Sieburth et al., 1978). Phytoplankton are known as planktonic photoautotrophs producing their own food through the process of photosynthesis. They inhabit the upper surface of the water column and down to the limit of penetration of light (Simon et al., 2009). Many phytoplankton are capable to drift passively along the water current (Simon et al., 2009). They are the main primary producer in the aquatic ecosystems and contributed about 50% of net primary productivity on Earth.

The name of phytoplankton provide two unique meanings which means that phyto is called as "plant" and plankton is known as "wanderer" in the Greek words. They can be categorized into two major groups which were non-motile and fast-growing diatoms that incapable to propel themselves through the water, and another were motile flagellates and dinoflagellates, which able to drift vertically in the water column in response to light (Reynolds, 2006). According to Reynolds (2006), phytoplankton differ widely in physical and chemical requirements due to their rapid population growth. Both diatom and dinoflagellates possess their own unique characteristics which make them vary in respect to their motility, cell-wall composition and embellishment, alimentary and reproductive strategies.

Barbosa (2009) stated that phytoplankton can be distinguished based on their cell size and shape. They can be differentiated into micro-phytoplankton (20-200 µm), nano-phytoplankton (2-20 µm) and picophytoplankton (0.2-2 µm). Micro and nano-phytoplankton can be easily identified by using the optical microscopy whereas picophytoplankton only can be identified through fluorescence techniques due to its tiny size.

2.1 Phytoplankton Diversity

Diatoms are classified as belonging to the division Chrysophyta and members of class Bacillariophyceae. Diatoms are unicellular, non-motile and photosynthesizing algae which live solitary but sometimes form colony or chains of cells (Stafford, 1999). They are divided into two orders which are Centrales and Pennales. They are found in both marine and freshwater ecosystem. Both benthic and planktonic forms exist. They required the presence of light to carry out photosynthesis; therefore they are one of the primary producers in aquatic habitats and form the base of the major food web. They are the primary food source to the freshwater and marine organisms.

The cell wall of diatom is made up of silica (SiO_2) known as frustule. Each frustule have two valves, which fit like a petri dish and girdle elements or girdle bands, which attached to the edge of the valves. According to the information obtained from Stafford (1999), the older and slightly larger valve was termed as epivalve; the newer and smaller valve was termed as hypovalve while the vertical lip or rim of the epitheca is called the epicingulum. The epicingulum enclose tightly with the hypocingulum of the hypotheca.

Dinoflagellates are classified as the members of the class of Dinophyceae. Dinoflagellates are separated into two groups which are unarmored and armored. The position of the girdle will determine the morphological form of the genera. The cell wall of armored dinoflagellates were made up of cellulosic plates which were organized in an exact orientation called as “plate tabulation” (Stafford, 1999). These specific plates only can be observed under the microscope and are useful in the identification of dinoflagellates species. Besides that, dinoflagellates have the unique features like spines, horns, and wings which are help to protect them from the predator, uptake of nutrient and aid in buoyancy within the water column. They possess two perpendicular flagella which aid in cells’ movement.

Blue green algae are classified as belonging to the class of Cyanophyceae. Blue green algae can also be called as cyanobacteria which can be identified based on their morphology. Blue green algae exist in two growth forms which are unicellular and filamentous. They are photosynthetic prokaryotes which undergo the process of photosynthesis to produce energy using chlorophyll *a* and various accessory pigments. They are widely distributed in lakes, ponds, springs, wetlands, streams, and rivers. According to Yadav et al. (2011), cyanobacteria were prokaryotic because they were lack of nuclei and other organelles inside their cells. Their cell walls are made up of peptidoglycan which is gram-negative. Blooming of cyanobacteria varied from olive-green to black-green color according to their density and species (Stafford, 1999). They possess a specialized feature, heterocysts which is able to fix the atmospheric nitrogen and assimilated into cellular nitrogen when there is deficiency of nitrogen. Not only that, they contained gas vacuoles which provide buoyancy to the cells and colonies, allow them to float on the surface water (Yadav et al., 2011).

Euglenoids are classified as belonging to the class of Euglenophyceae. Euglenoids are characterized as both photosynthetic and phagotrophic microalgae. They exist in various forms such as fusiform, elongate, spherical, flattened or twisted cells. Their cell walls are made up of proteinaceous pellicle instead of cellulose. The movements of euglenoids are controlled by a mode of locomotion known as metaboly (Stafford, 1999). They also have two flagella that aid in locomotion. They obtain energy through photosynthesis (autotrophic) or by absorbing (heterotrophic) or engulfing (phagotrophic). High organic content in the lakes or rivers may indicate the presence of euglenoids (Stafford, 1999).

2.2 Reproduction of Phytoplankton

Phytoplankton undergo reproduction through either sexual or asexual. Asexual reproduction is the production of daughter cells that inherited the same genetic copies as their parent cells. The new individual cells were formed through various asexual mechanisms such as fragmentation, binary fission and spore formation (Fizawati, 2012). Most of the phytoplankton reproduce asexually through the formation of spores within the parent cell where the spores grow into a single algal cell or divide mitotically into numerous cells. Spore formation are mostly found in algae. They produced sporangia where each of the sporangium produced either non-motile spores called aplanospores or motile spores called zoospore (Stafford, 1999).

However, some diatom and dinoflagellates are common to reproduce asexually by simple cell division. Some of them formed and produced a resting spore when the environmental condition was unfavourable (Waite & Harrison, 1992). According to Waite and Harrison (1992), diatoms formed a specialized sexual-reproductive structures called auxospore in order for them to survive under the adverse environments. For dinoflagellates, they have motile sexual phases which allow them to produce cysts or normal vegetative cells depend on prevalent conditions.

Sexual reproduction is rarely occur in phytoplankton. It involved of two reproductive structures which were male gametes and female gametes (Waite & Harrison, 1992). The production of reproductive gametes either from the same plant (monoecious) or from different plants (dioecious). The fusion of both male gametes and female gametes produced a haploid zygote (Dassow & Montresor, 2011).

2.3 Ecological Importance of Phytoplankton

Phytoplankton play a vital role in food supply and energy to the other living organisms in the higher trophic level. They act as a primary producer in the food chain to supply the food directly or indirectly to other marine organisms that situated on the higher trophic level. Besides that, phytoplankton species are primarily autotrophic organism in the aquatic and marine food webs where they are capable to build organic matter from the residual inorganic materials that deposited in the ocean bed. According to Falkowski (2012), the rate of energy released during the accumulation of inorganic matter will store by these tiny organisms to determine the basic primary productivity of the particular ecosystem.

Biologists assumed that the organic matters absorbed by the phytoplankton would breakdown into two ways (Falkowski, 2012). In the first, phytoplankton that inhabit on the subsurface of water column would be consumed by the other heterotrophs, animals and other microorganisms, they would breakdown the phytoplankton's organic matter to acquire energy and nutrients for its metabolism. Hence, the carbon dioxide that produced would be utilized by other phytoplankton for their cells' reproduction and growth. In a second way, the dead materials of the phytoplankton and other heterotrophs would sink slowly into ocean floor and decompose by the microorganisms. Due to deep and cold water in the bottom of ocean, there was rarely mixing of cold water with the warm water at the upper surface of the ocean (Falkowski, 2012). Thus, carbon dioxide would be deposited in the deep ocean.

After the several decades, the ocean circulations that occur would replace the upper surface water with deep and nutrient-rich water. At the same time, carbon dioxide would transported to the upper surface and later release to the atmosphere. This is how the upper layer acts as a biological pump to pump the carbon dioxide into the ocean, to reduce the atmospheric levels of carbon dioxide. It can be concluded that phytoplankton are significantly important to contribute almost half of the world's total primary production in altering the carbon cycle in the atmosphere. Eventually, it would indirectly help to reduce the world's global warming (Falkowski, 2012).

Recent years, many countries have been practicing to use algae and diatoms to monitor environment condition and water quality. Algae were ideally suitable for water quality assessment because they have rapid reproduction rates and very short life cycles which making them valuable indicators of short-term impacts (Wan Maznah, 2010). Besides using algae as bio-indicator, diatoms were extensively use in water quality monitoring because they were widely distributed and capable to tolerate in a wide range of ecological conditions with the high reproduction rate and high sensitivity towards water chemistry and nutrient variation (Michels, 1998). Diatoms gave the most accurate data than other chemical and zoological assessment according the water quality indices that had revealed. Canada, India and Costa Rica were the examples of countries that have been using diatom as the bio-indicators to monitor water pollution. A study was carried out by Wan Maznah and Mansor (2010) using the diatom to measure the degree of pollution in the Penang River system. The study indicated that sensitivity of certain diatom towards the different degree of pollution.

Another study was done by Paerl et al. (2010) to measure the ecological change in Neuse River Estuary of USA. In this study, the use of diagnostic phytoplankton group-level photo pigments to measure the impact of anthropogenic activities followed by climatic perturbations acting on multiple periods. Phytoplankton were widely used because they were able to grow rapidly and very sensitive in detecting the wide range of changes of environmental conditions (Paerl et al., 2010). Not only that, phytoplankton have been used in the monitoring of heavy metals concentration in seawater. They uptake those heavy metals from the aqueous environment through adsorption and assimilation. The metals ions were adhered to the algal surface to form metal-ligand complexes and subsequent diffuse across the cell membrane (González-Dávila, 1995). When the release of the extracellular organic matter with metal complexing properties into environment, it will help to lessen the concentration of free metal ions in the aqueous environment. Hence, it might help to alleviate the toxic effects on aquatic organisms (González-Dávila, 1995).

3.0 Materials and Methods

3.1 Study Area

This study was conducted in the UNIMAS lakes located in West and East campus. Samplings were done from three lakes named West Campus Lake (WC), East Campus Lake 1 (EC1) and East Campus Lake 2 (EC2) in November 2014 and February 2015. Three stations were established in each lake (Figure 1 & 2). The coordinate of each station was recorded and determined by using a Global Positioning System (GPS) device.

Table 1: GPS readings for every station in November 2014 and February 2015

Station	**Global Positioning System (GPS) reading**	
	November 2014	**February 2015**
WC1	N 01º28´10.4´´, E 110º25´55.2´´	N 01º28´13.1´´, E 110º25´49.8´´
WC2	N 01º28´09.0´´, E 110º25´37.0´´	N 01º28´08.9´´, E 110º25´36.8´´
WC3	N 01º27´58.3´´, E 110º25´30.5´´	N 01º27´57.9´´, E 110º25´30.5´´
EC1-1	N 01º27´49.6´´, E 110º26´59.6´´	N 01º27´49.6´´, E 110º26´59.5´´
EC1-2	N 01º27´47.0´´, E 110º26’57.9´´	N 01º27´47.0´´, E 110º26´57.9´´
EC1-3	N 01º27´45.0´´, E 110º26’58.3´´	N 01º27´45.9´´, E 110º26´59.7´´
EC2-1	N 01º27´37.6´´, E 110º26’57.6´´	N 01º27´37.5´´, E 110º26´57.4´´
EC2-2	N 01º27´36.5´´, E 110º26’56.1´´	N 01º27´36.5´´, E 110º26´56.1´´
EC2-3	N 01º27´36.5´´, E 110º26’56.1´´	N 01º27´35.9´´, E 110º26´59.5´´

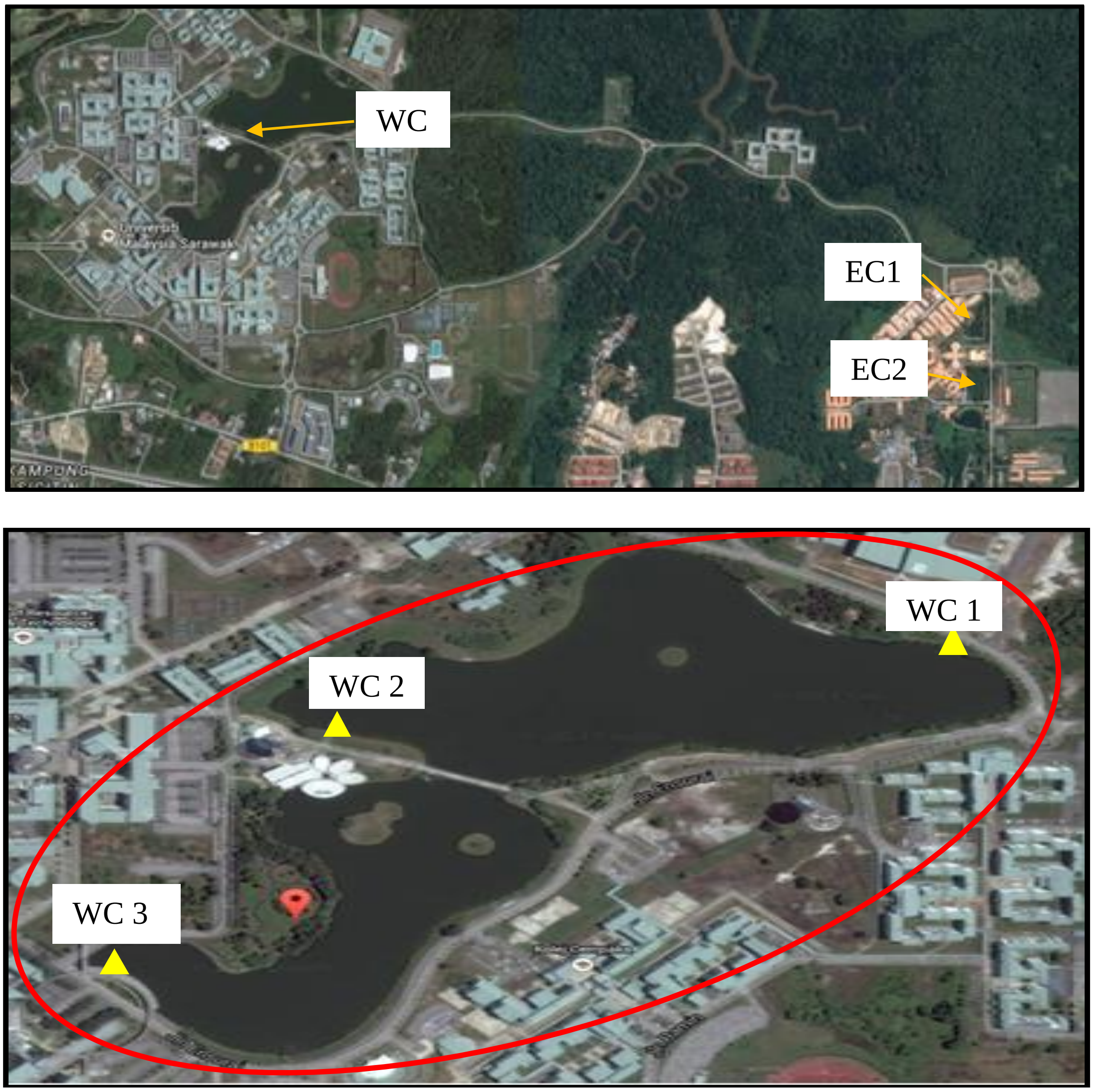

Figure 1: Map showing the sampling stations in the West Campus Lake (WC) in UNIMAS, Sarawak.

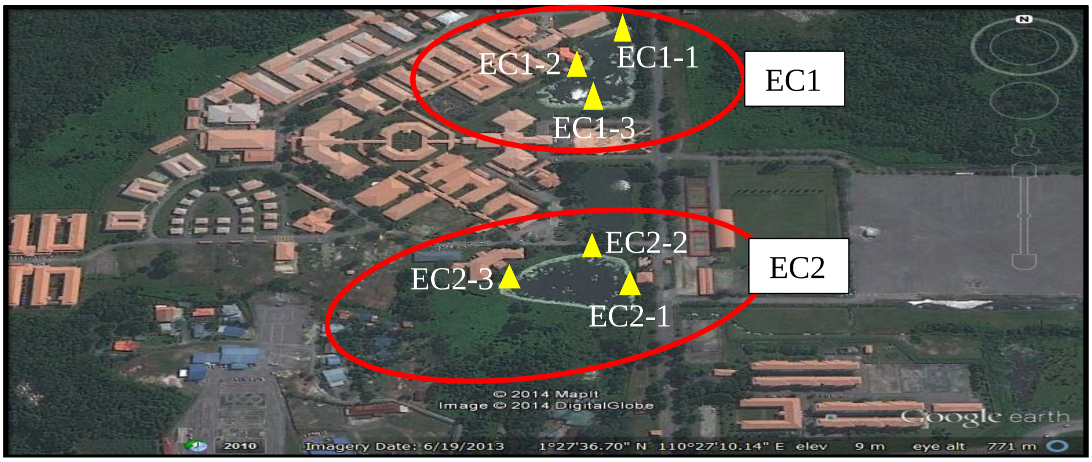

Figure 2: Map showing the sampling stations in East Campus Lake 1 (EC1) and East Campus Lake 2 (EC2) in UNIMAS, Sarawak.

(Source: Google Earth)

3.2 Phytoplankton Collection

Phytoplankton samples were collected using a plankton net (20 µm mesh size) (Lee & Lee, 2011). The plankton net was towed horizontally. The samples were kept in a 500 ml opaque polyethylene bottle and preserved in Lugol's iodine solution and labelled. All the samples taken from the sampling stations were kept in a cooler box and brought back to the laboratory for further analysis.

The samples were observed under inverted microscope (Olympus IX51) and compound microscope (Motic BA210 Series) for taxonomic identification using available reference materials such as Stafford (1999), Tomas (1997), Round et al. (1990), Cupp (1943) and other relevant sources. The phytoplankton samples were identified to the lowest taxonomic level.

3.3 Physico-Chemical Parameters

Water parameters such as dissolved oxygen (DO), turbidity, pH, depth and temperature were measured *in-situ* using DO meter, turbidity meter, depth finder, pH and temperature meter. Triplicate readings of each parameter at each station were measured and recorded.

3.4 Water Collections

Water samples were collected using a Van Dorn water sampler for chlorophyll *a* and nutrients analysis. Triplicate water samples were taken at each station. The water samples were kept in pre-acid washed bottle samples, labelled and brought back to the laboratory. The water samples for the chlorophyll *a* analysis were stored in dark and keep in refrigerator (4 ℃) before analyzed within 24 to 48 hours. However, the water samples for the nutrient analysis were filtered first and stored in a deep-freezer at -20 ℃ before analysis.