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JUDUL: THE DIVERSITY AND PERIODICITY OF MARINE PHYTOPLANKTON AT THE JETTY AREA OF UMS

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THE DIVERSITY AND PERIODICITY OF MARINE PHYTOPLANKTON AT THE JETTY AREA OF UMS

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CONSERVATION BIOLOGY

SCHOOL OF SCIENCE AND TECHNOLOGY

UNIVERSITY MALAYSIA SABAH

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DECLARATION

I declare that this thesis is my own composition, it does not contain any material published or written by another person except where due reference is made in the text.

March 2005

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ABSTRACT

Periodicity in phytoplankton population as well as phytoplankton abundance and physico-chemical factors affecting the abundance and periodicity were investigated in this study. Quantitative and qualitative sampling was carried out between August 2004 and November 2004 at two sampling stations located at the UMS jetty area. Three divisions of marine phytoplankton were identified which are Bacillariophyta, Pyrrophyta and Cyanophyta. Fifty five species of marine phytoplankton were identified during this study with Bacillariophyta as the dominant species in terms of total species number and cell density during the research period. The highest phytoplankton abundance was determined in the month of October 2004. Phytoplankton diversity declined to the lowest level in the month of November 2004. Phytoplankton cell numbers found in this study were lower than those previously reported and in contrast to many previous findings carried out at Sepanggar Bay. A significant positive relationship was found between salinity and phytoplankton abundance ($r=0.68$, $p<0.05$). In general, significant negative relationships were found between phytoplankton abundance and abiotic factors which are as pH ($r = -0.15$, $p<0.05$); DO ($r = -0.50$, $p<0.05$); turbidity ($r = -0.13$, $p<0.05$) and temperature ($r= -0.29$, $p<0.05$).

ABSTRAK

Kajian ini dilakukan untuk mengetahui kekalaan dalam populasi fitoplankton dan kelimpahan fitoplankton serta faktor-faktor fiziko-kimia yang mempengaruhi kelimpahan fitoplankton. Kaedah persampelan kuantitatif dan qualitative telah dilaksanakan di antara bulan Ogos 2004 dan bulan November 2004 di dua stesyen persampelan di jetty UMS. Tiga divisi fitoplankton telah dikenalpasti dalam kajian ini iaitu Bacillariophyta, Pyrrophyta dan Cyanophyta. Lima puluh lima species fitoplankton telah dikenalpasti dan divisi Bacillariophyta merupakan divisi dominan dalam erti kata densiti sel dan jumlah species yang telah dikenalpasti di kawasan jetty UMS. Jumlah fitoplankton adalah terbanyak pada cuaca panas. Jumlah fitoplankton yang tertinggi dicatat pada bulan Oktober 2004. Diversiti dan densiti fitoplankton menurun pada bulan November 2004. Sel fitoplankton yang telah dikenalpasti dalam kajian ini adalah lebih rendah berbanding dengan kajian-kajian terdahulu yang pernah dijalankan di Teluk Sepanggar. Kelimpahan dan densiti fitoplankton berkorelasi secara positif dengan saliniti ($r=0.68$, $p<0.05$). Ini merupakan satu penemuan menarik kerana dalam kajian-kajian sebelum ini saliniti berkorelasi secara negatif. Secara am, hubungan korelasi negatif telah diperolehi antara parameter-parameter fiziko-kimia yang lain dengan densiti fitoplankton seperti yang tersenarai pH ($r = -0.15$, $p<0.05$); DO ($r = -0.50$, $p<0.05$); turbidity ($r = -0.13$, $p<0.05$) dan suhu ($r= -0.29$, $p<0.05$).

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μm	micrometer
m	meter
mL	mili liter
ppt	parts per thousand
%	percentage
cm	centimeter
$J\ cm^{-2}\ s^{-1}$	joule per centimeter per second
Cell/mL	cell over mili liter
NTU	turbidity

CHAPTER 1

INTRODUCTION

1.1 Phytoplankton

The scientific study on algae is known as "phycology". Algae are a group of organism that contains chlorophyll and its reproduction cell is not protected by futile cells. Algae can be initiated almost anywhere oceanic and sometimes at moist places and are collectively referred as phytoplankton (Baharuddin, 1987).

Phytoplankton goes under the surface of water to produce carbohydrates via a set of chemical reactions termed photosynthesis. The phytoplankton comprises of a vast, diverse assemblage of organisms which are united by their tiny size and drifting life mode, rather than by genetic relatedness. They have inhabited earth's seas for millions of years, and their lives have changed the face of our planet, for their photosynthesis has generated much of the oxygen in our atmosphere, and when each cell's life is done, their shells have drifted to the sea floor to form its sediments. Marine phytoplankton is a group of autotrophic plankton with pigment or chromatophore.

Together with benthic algae, they constitute the primary production in ocean. Phytoplankton is distributed widely in epipelagic waters in oceans of the world, but is restricted to the upper euphotic layer (Baharuddin, 1987). Phytoplankton has a variety of sizes ranging from 200 µm to 1mm. Algae can be classified into several phylum according to its colour. Ahmad et al. (1992) has classified phytoplankton into phylum such as blue-green algae (Cyanophyta), green algae (Cholorophyta), diatoms (Bacillariophyta), dinoflagellates (pyrrophyta), yellow algae (Chrysophyta), red algae (Rhodophyta), brown algae (Phaeophyta), Euglenophyta and Crytophyta.

Marine phytoplankton can be classified based on their basic cell organization which are *Prokaryotae* (Bacteria and Cyanophyta) and *Eukaryotae* which is unicellular algae compromising Bacillariophyta, Chlorophyta, Chrysophyta and Xantophyta. The Cyanobacteria are actually prokaryotic (without a nucleus) organisms. Among the most common Eukaryotes are the diatoms, the dinoflagellates and the coccolithophorids (Zhong, 1989). Table 1.1 on the next page shows the basic differences between properties of prokaryotic and eukaryotic phytoplankton cells.

Phytoplankton bloom results in lower water quality, health related problems directed to toxic gas exposure when bloom thus resulting to lost of commercial value of the locale as a recreational platform (Vukadin, 1990). Micro algal "bloom" brings effects to the ecosystem mainly reducing the invertebrate biomass and prevents marine life movements (Phycol, 1994).

Phytoplankton, are significant building blocks in the world's food chain and grow with the assistance of sunlight and the pigment chlorophyll. Chlorophyll, which absorbs red light (resulting in the ocean's blue-green colour) is considered a good indicator of the health of the ocean and its level of productivity. The effects of phytoplankton "bloom" brings pollution to water quality, health problems due to the release of toxic gases and the lost of the ocean as a recreational park (Vukadin, 1990). Micro algal "bloom" can affect the ecosystem by reducing the invertebrates' biomass and prevent fish's movement (Phycol, 1994).

Table 1.1: Basic differences between properties of prokaryotic and eukaryotic phytoplankton cells. (Zhong,1989).

CHARACTERISTICS	PROKARYOTAE(CYANOPHYTA)	EUKARYOTAE
Diameter of cell	1-55μm (commonly 4μm)	2μm-2mm (commonly 10-50μm)
Nucleus	Absent	Present
DNA	Not associated with histone	Histones present in the nucleus
Respiration and Photosynthesis	On overall membrane	On membrane speciation
Ribosome	70s	80s
Streptomycin	Sensitive	Insensitive
Chloramphenicol	Sensitive	Insensitive
Cycloheximide	*Insensitive*	*Sensitive*
Composition of cell wall	Peptidoglycan	Others
Penicillium	Sensitive	Insensitive
Nitrogen fixation	In some species	Absent
Tolerate low oxygen	In dark	Obligate aerobes
Temperature tolerance	*High (70-100°C)*	*Relatively low (<40°C)*

Diatoms are the most common type of phytoplankton discovered scattered vastly all around the ocean. Diatoms contribute 20% to 25% of primary product in this world (Shamsudin, 1987). Diatoms are unicells that share the feature of having a cell wall made of silicon dioxide. This opaline or glass frustule is composed of two parts (valves), which fit together with the help of a cingulum or set of girdle bands. The taxonomy of diatoms is based in large part on the shape and structure of the siliceous valves. Two major groups of diatoms are generally recognized: the centric diatoms exhibit radial symmetry (symmetry about a point) and have oogamous sexual reproduction, while the pennate diatoms are bilaterally symmetrical (symmetry about a line) and produce ameboid gametes that are morphologically similar but may be physiologically different. Chloroplasts of diatoms are variable, but consistent within most taxa. Chloroplasts may be many small discs, a condition found in most centric diatoms and some (araphid) pennates, or few large, plate-like chloroplasts are found in the majority of pennate taxa (Baharuddin,1987).

Phytoplankton diversity is greater in life-forms with medium productivity characterized as the relation between energy consumed and biomass produced. In a research undertaken by Xabier Irigoien, it is shown that, in the case of algae – phytoplankton – these do, in fact, reach the maximum point of diversity with medium productivity. The dominant pattern linking diversity and productivity is unimodal. In this pattern, when the productivity of the species is small, its diversity is also small; when productivity is medium, diversity is maximum and, when the productivity increases, the diversity diminishes once again. In other words, the diversity has a triangular pattern.

In the case of phytoplankton there could be a number of reasons why diversity is high when productivity is moderate. The history of the community, the distribution of habitats, the struggle to find food and resources, the relationship between different species, the abundance or lack of food, and the size of the species could be the cause of this diversity pattern. For example, if on the coast the waters are rich in nutrients and the productivity is high, there will be many predators and, thus, only those species of phytoplankton best adapted and prepared to face up to the predators will survive. The result is scant diversity. On the other hand, if the waters lack sufficient nutrients and productivity is small, few species will survive and, once again, diversity will be low. When the nutrients are sufficient and the productivity is medium, is when diversity amongst the phytoplankton is at its maximum.

On the biological side, phytoplankton cell division is offset by mortality due to trophic interactions such as grazing and viral lysis. If physical conditions are stable, the phasing of many phytoplankton growth processes to the daily light-dark cycle (Chisholm 1981; Prézelin 1992) may allow growth and grazing rates to be estimated from diel cell concentration changes (André et al., 1999). Stability is the exception, however, especially in coastal waters where physical processes can be a dominant source of variability in phytoplankton biomass.

In recent years it has become more evident that marine phytoplankton are distributed in patterns that are highly variable in space and time. This evidence has come from a variety of sampling approaches ranging from shipboard- or mooring-based measurement of in vivo chlorophyll fluorescence to satellite-based assessment of ocean color (Dickey, 2001). Despite these valuable measurement approaches, our knowledge of the factors that regulate phytoplankton distributions at the mesoscale and smaller continues to be limited by inadequate sampling; the outstanding problems include limited coverage and resolution in space and time as well as the need to characterize properties such as the composition, size distribution, and growth rate of the phytoplankton community.

Physical factors such as temperature and light and chemical factors such as dissolved oxygen (DO) and pH are utmost important factors in determining water quality and also the growth of algae. These factors can influence the dynamics of the phytoplankton community in the ocean. Physical-chemical factors have a direct association with the routine of nutrient intake and the dominance of a population. There for the dominating species would be those that can adapt well to the changes of the environmental factors surrounding it. Alternatively, if the species does not adapt to the environmental changes it would be suppressed and thus species burden would take place (Norhafiza, 1994). Light increases cellular iron (Fe) requirements for phytoplankton because it affects the functional organization of the photosynthetic apparatus.

According to Boney (1975), phytoplankton acclimates to low photon-flux densities by changing pigmentation and abundance and stoichiometry of Fe-rich electron transport components and reaction centres. Photoacclimation is widely observed in oceanic phytoplankton and it allows algae to maintain fast rates of photosynthesis. The costs of such an acclimation are predicted to be high when light levels are near the compensation irradiance. There is about a 50-fold increase in Fe demand for photolithotrophic growth at low light compared to full sunlight (André et al. 1999). Under low light and low temperature conditions phytoplankton cells grow more slowly.

The objective of this thesis is to study the periodicity and the diversity of marine phytoplankton off the coastal waters of UMS. The periodicity and diversity of phytoplankton is effected by many environmental factors such as nutrient source, seasonal changes, temperature, sun light, wind agitate and predator activity (Reynolds, 1988). This study is related to the factors affecting the presence of phytoplankton based on environmental factors. Another aim of this study is to determine which algal species are present during blooms, as well as what chemical and physical factors may be responsible for bloom initiation.

1.2 Justification of Research

I. Presence of red tide has been detected at the jetty area. Red tide together with high productivity of phytoplankton and algal bloom can affect aquaculture productivity.
II. To monitor the water quality at the UMS jetty area as BMRI (Borneo Marine Research Institute) uses the water from the jetty area for aquaculture purposes.

1.3 Research Objectives

I. To determine the diversity and periodicity of phytoplankton species present during sampling period.

II. To study the effects of the physical environment on phytoplankton abundance.

III. To study the variations in phytoplankton dominance, periodicity and density at both the sampling stations.

1.4 Research Hypothesis

The intended hypothesis tests to achieve the objectives are listed below.

I. Phytoplankton cell density is the same at both the sampling stations at the study site.

II. The density of phytoplankton fluctuates regularly according to time which is weekly.

III. Parameter such as light, temperature, salinity, pH and DO affects the distribution of phytoplankton as shown in Table 1.2.

Table 1.2: Parameters affects on phytoplankton distribution

Parameters	Effects on phytoplankton distribution
Light	High light incident increases phytoplankton
Temperature	High temperature increases phytoplankton
Salinity	High salinity decreases phytoplankton

CHAPTER 2

LITERATURE REVIEW

2.1 Factors affecting phytoplankton growth and abundance

The growth of any plant requires light, carbon dioxide and water for photosynthesis, mineral nutrients in solution, and a appropriate ambient temperature for metabolic activity (South *et al.,* 1987). For marine phytoplankton water and carbon dioxide supply are not limited but the need to remain where there is sufficient light proves to be critical for an organism with a tendency to sink.

2.1.1 Light

The accessibility of sunlight as the foundation of dynamic energy is an obvious feature of primary production. In aquatic habitats, four characteristic must be considered, the resources by which phytoplankton cells exploits this radiant energy; the intensity of the incident light, the immediate changes in the light on passing from air to water, and the extent to which with increasing depth this light both penetrates and endures further modification (Nybakken, 1990). Illumination in all habitats will depend on the sun's position with latitude and season and on the cloud cover. In temperate regions the light intensity on a bright summer day may be halved if clouds cover the sun. By disparity, on a clear winter day with bright sunlight, the light intensity may be only one-fifth of that on a clear summer day, and with cloud cover this may be reduced to one-tenth. Consequently there will be variation in light intensity over the course of a day, and in addition the wavelength composition will change through the day with passage of the sun (Steinberg *et al.,* 1988).

According to Boney (1975), in north temperate regions the daily illumination reaches a maximum intensity in May and June, declining to around one-ninth of this summer level during December and January. In the tropics a daily illumination similar to that of the temperate summer lasts through the year apart from in the rainy season. In cold regions ice will allow light penetration into the underlying water, but snow cover reduces this. With fresh water reservoirs some influence over the growth of phytoplankton is enviable and reduced illumination has been considered as a possible measure (Nybakken, 1990). Unnecessary algal growth will both clog the filter beds and affect the taste of water. Various methods of artificial shading for control of plant growth have been suggested for example the use of plastic netting or of aluminized plastic sheeting. Seasonal light intensity is closely related with temperature albeit monthly changes in sea and lake temperature are outpaced by variation in illumination (Dokulil *et al.,* 1996). The presences of light have bearing on the content of chloroplast and its pigmentation in a phytoplankton. This is further described below.

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