SUITABLE ALGAL SPECIES FOR CLOSE TANK SYSTEM

ABBY BINTI ZAINAL ARIFFIN

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The materials of this thesis are original except for quotations, excerpts, summaries and references, which have been duly acknowledged.

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2. **EXAMINER 1** MISS ZARINAH WAHEED	____________________
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Abstract

Algae have shown to be a very good water quality indicator. In this study, algae were introduced as biological filter. The study has been conducted from 13th September 2004 until 24th January 2005. It consisted of water quality observation both physical and chemical parameters. It was conducted in the reef tank system of Wet Laboratory of Borneo Marine Research Institute. Comparisons were made between three tank systems, which consisted of three different species of macro algae, and a control tank that only consisted of mainly live rocks. Results showed that there was no significant difference in *in situ* parameters such as salinity, temperature and dissolved oxygen between all tanks. However, there was a significant difference in pH between all tanks. Results also showed that there was no significant difference in nutrient parameters between the three experimental tanks but there was a significant difference between experimental tanks and control tank. Overall, value of nutrients recorded lower in experimental tanks which consisted of algae as bio filter than control tank which did not contained algae. This concluded that with the presence of algae, they helped to reduce excess nutrients in the tank system. Among those three species, *Enteromorpha clathrata* was identified as the best algal species in close tank system.

Abstrak

Alga merupakan penunjuk kualiti air yang baik. Dalam kajian in, alga telah digunakan sebagai penapis biologikal. Kajian ini telah dijalankan bermula 13 September 2004 sehingga 24 Januari 2005. Kajian ini meliputi pemantauan terhadap kualiti air bagi kedua-dua parameter iaitu secara in situ dan analisis nutrien. Kajian ini dijalankan di sistem tangki terumbu karang di Makmal Basah, IPMB. Perbandingan dibuat ke atas tiga sistem tangki yang mana mengandungi tiga spesies rumpai laut yang berbeza dengan satu tangki kawalan yang hanya mempunyai 'live rocks'. Keputusan mendapati terdapat tiada perbezaan yang signifikan dalam parameter *in situ* seperti saliniti, suhu dan oksigen terlarut di antara kesemua tangki. Namun terdapat perbezaan yang signifikan dalam pH di antara ketiga-tiga tangki yang dikaji serta tangki kawalan. Secara keseluruhannya, nilai nutrien dicatatkan lebih rendah di dalam tangki kajian, yang mempunyai alga sebagai penunjuk biologikal, berbanding tangki kawalan yang tidak mempunyai alga. Ini memberi kesimpulan bahawa dengan kehadiran alga, mereka membantu mengurangkan lebihan nutrien di dalam sistem tangki tersebut. Daripada ketiga-tiga spesies yang dikultur, *Enteromorpha clathrata* telah dikenalpasti sebagai spesies alga yang sesuai di dalm sistem tangki tertutup.

CONTENTS

LIST OF SYMBOLS

°C	degree Celcius
µg at/L	micro gram atoms per litre
µg /L	micro gram per litre
mg/L	mili gram per litre
%	percentage
ppt	part per thousand
ppm	part per million
w/v	weight per volume
mm	millimeter
C	Carbon
CO_2	Carbon dioxide
O_2	Oxygen
N	Nitrogen

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Nowadays, as our interest in marine aquarium has expanded from only rearing fish to keeping other invertebrates (such as corals), the need for a closer copy of natural environment has risen. Keeping fish in a tank taught us about the Nitrogen Cycle. Apart from pollutants in the cycle itself, other pollutants such as phenols, fatty acids, proteins, polypeptides and amino acids- which will be slowly converted to ammonia, can also affect the more sensitive invertebrates (Emmens, 1995).

Pollution is not just that. Keeping the whole maintenance of a tank system; which includes pH, salinity and dissolved gases level are seems tedious and fussy. The water in the system needs to be changed frequently to avoid accumulation of waste and most importantly to keep the system itself running properly while ensuring the survival of organisms in it.

In this perspective, I will be using the concept of biological filtration to overcome problems that will arise in the setting up of a tank system. Therefore in this project, I will be emphasizing more on macro algae; one of the sources which can be easily obtained as they grow abundantly in the environment.

1.1.1 Algae

Algae are a highly diverse group of organisms that have important functions in aquatic habitats (Stevenson *et al.*, 1996). The term *alga* (plural algae) is not an easy word to define. Bold and Wynne (1978) note that algae "share the more obvious characteristics with other plants while their really unique features are more subtle". However, Trainor (1978) states that these 'simple' plants are not really simple at all (Dawes, 1981). He presented a technical definition to explain algae as; photosynthetic, non-vascular plants that contain chlorophyll *a* and have simple reproductive structures. At the same time, according to Lee (1999), algae are thallophytes (plants lacking roots, stems and leaves) that have chlorophyll *a* as their primary photosynthetic pigment and lack a sterile covering of cell around the reproductive cells.

Algae live in both fresh and salt water, and their metabolic activities profoundly affect the Earth's ecology. They are the Earth's major fixers of carbon dioxide (Ingraham and Ingraham, 1995). They can generally be divided into macroscopic (which can be seen by human eye) and microscopic (phytoplankton). Macroscopic algae, commonly referred to as macroalgae or seaweeds (Dawes, 1981), are large plant-like structures commonly found in coastal waters worldwide.

Macroalgae appear in a variety of colours and forms. They are divided into three groupings based on their pigments which are:

i) Red algae (Rhodophyta)

ii) Brown algae (Phaeophyta)

iii) Green algae (Chlorophyta)

Generally, the divisions of algae are distinguished by a variety of chemical and morphological differences (Bold and Wynne, 1985; Lee, 1989). All divisions have chlorophyll a, but different divisions can also have chlorophylls b, c or d. Chlorophylls are the pigments that mediate the basic reactions of photosynthesis by converting light energy into chemical energy (Ingraham and Ingraham, 1995). Besides chlorophyll, other distinctive accessory pigments such as phycobilins and fucoxanthin are also characteristics of different algal divisions (Ingraham and Ingraham, 1995; Stevenson, 1996; Lee, 1999). Both accessory pigments collect light energy and pass it on to the chlorophylls (Ingraham and Ingraham, 1995).

The different divisions also have chemically different cell walls and storage products, or they have distinctive forms of motility or numbers of flagella (Morris, 1988; Chapman and Chapman, 1990; Lee, 1999). Ultra structural features, such as number of membranes around chloroplasts; also distinguish the different divisions and indicate the algae have many ancestors and are an evolutionarily diverse group (Stewart and Mattox, 1980; Gibbs, 1981; Cavalier-Smith, 1986; Lee, 1990).

By various taxonomic schemes, the number of algal divisions range from 4 to 13, with as many as 24 classes and about 26, 000 species (Bold and Wynne, 1985; Raven and Johnson, 1992). The number of recognized species probably greatly underestimates the actual number of species because many habitats and regions have not been extensively sampled and many algae are very small and hard to distinguish from each other (Stevenson *et al.*, 1996).

1.1.2 Location of study

My study is on the closed tank system, which is situated in the wet lab of Borneo Marine Research Institute. There are nine tanks, that comprise upper and lower tanks and three tanks, that only consist of the upper tanks. The upper tank is the main tank and the lower tank is the algae tank. Water in both upper and lower tanks is circulated within the tanks itself; while water in those three upper tanks circulate within the three tanks itself.

The room temperature ranged of 23 to 27°C. The lighting system was switched on from 7 am to 7 pm for the coral (main) tank and from 7 pm to 7 am for the algae tank.

The tank system studied is a closed tank system. The closed tank system is a self-sustaining tank system where the water cycle circulates between the tanks involved. In this case, there are two tanks involved in a system. The first tank is the coral tank and the other is the filter tank whereby both tanks undergo daytime and nighttime processes; photosynthesis and respiration. In the filter tank, seaweeds function as biological filters.

1.1.3 Concept of biological filtration

Biological filtration is a concept to explain how waste products of the reef inhabitants are converted to a non-toxic state in a natural process known as the Nitrogen Cycle. This process is carried out by various types of bacteria; the nitrifiers, denitrifiers and heterotrophs that live on every surface of the tank.

In the tank, ammonia comes from two main sources, which are:

i) the breakdown of organic material by heterotrophic bacteria

ii) bi-product of animal respiration

The overall chemical formula for biological filtration is:

$$2NH_3 + 3O_2 \longrightarrow 2NO_3^- + 6H^+$$

There are two main processes in the Nitrogen Cycle, which are why biological filters are designed as:

i) Mineralization (Nitrification)

Biological filters are designed to encourage colonization, which are formed by nitrifying bacteria. This system focuses on rapid conversion of ammonia to nitrate. In them, mineralization of nutrients occurs. Nitrogen that enters the system as complex organic molecules (proteins) in food is reduced to its simpler, mineral components by biological activity.

ii) Denitrification

The chemical breakdown of complex organic matter by the action of heterotrophs is an essential step in the Nitrogen Cycle. The denitrifying bacteria act to reduce nitrate to nitrogen gas, which then will escape to the atmosphere. Bacteria living in the interior spaces of live rock carry out denitrification, and similar bacterial colonies can be encouraged to form in the substrate on the bottom of the tank. The overall chemical reaction for denitrification process is;

$$2NO_3^- + 6H^+ \longrightarrow N_2 + 3H_2O$$

1.2 Objectives of study

i) to identify algal species that would be a suitable candidate as bio filter in a closed tank system

ii) to compare water quality parameters between all experimental tanks and control tank

As a tool of investigation, the following were undertaken:

i) monitoring nutrient parameter levels in coral tank and algae tank

- nitrate
- ammonia
- phosphate
- calcium

ii) monitoring *in situ* parameter levels in the system

- salinity
- dissolved oxygen
- temperature
- pH

Significance of study

The use of algae as biological filter is hoped to be a source of alternatives for a more environmental friendly and low cost filtration system.

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