# DEVELOPMENT AND SUCCESSION OF MACROFOULING ORGANISMS ON ARTIFICIAL STRUCTURE IN THE SHALLOW COASTAL WATERS OF SABAH, MALAYSIA

**MOHD ALZAM BIN MOHD AFFANDY**



**BORNEO MARINE RESEARCH INSTITUTE**
**UNIVERSITI MALAYSIA SABAH**
**2022**

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**MOHD ALZAM BIN MOHD AFFANDY**



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VIVA DATE : **8 FEBRUARY 2022**



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1. **MAIN SUPERVSOR**
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# ABSTRACT

This study investigates macrofouling development on PVC panels materials deployed in Karambunai, Sabah. The experimental setup includes two sets of connected PVC pipe, frame in triangle shape attached to concrete blocks deployed at seafloor and kept afloat vertically underwater. The first set (upper) of frame positioned 2 m from water surface whereas the second set (bottom) attached 8 m below it. Total of 36 experimental PVC plates measuring 20 cm x 27 cm were tied on each three sides of the two different sets of frames. To investigate monthly macrofouling development, three panels were taken from each side of the two different frames. Pyhsico-chemical parameters of seawater such as sea water temperature, salinity, pH, turbidity, dissolved oxygen, depth, current speed, direction and light attenuation was also taken, along with water sample for water nutrient analyses such as nitrate, ammonia-nitrogen and total dissolved phosphate. These steps were done every 30 days, throughout 180 days of experiment, from April to September 2017. As a result, a total of 13 different species of sessile and motile macrofouling were found on the front side and the back side of the plates at 2 m and 8 m. For sessile species, in the first 90 days, *Lyngbya* sp. (algae) was the most abundant sessile species with percentage cover range from 70% to 90%. However, after 90 days, *Eudendrium* sp. (hydroid) (nearly 80%) and *Amphibalanus amphirite* (barnacles) (nearly 50%) replaced hydroid as the most dominant species. Based on three way-ANOVA on influenced of depths, submersion time and position, with the percentage cover of the sessile species, the calculations showed that these sessile species percentage covers were influenced significantly ($P<0.05$) by submersion time, depth and interaction between time and depth. As for motile macrofouling species, three species were identified as the dominant species which were *Perinereis* sp. (flatworm), *Etisus dentatus* (crab) and fish larvae from family Blenniidae. Based on two way-ANOVA on influenced of depths and submersion time, with the number of individuals of the dominant species, the calculations showed that these dominant species percentage covers were influenced significantly ($P<0.05$) by submersion time and depth. Through CCA analyses, these dominant macrofouling assemblages's number were influenced by pH, temperature, $K_d$, average rainfall distribution, current speed and submersion time. Although this experiment was cut short into six months, the research did give enough indication on the process of colonization and succession on macrofouling community that happened on the artificial structure. For future work recommendation, it is best to proceed the study by installing more artificial structures at more locations, to see a more elaborated succession and colonization process.

# *ABSTRAK*


***PENGEMBANGAN DAN PENGGANTIAN ORGANISMA 'MACROFOULING' DI ATAS STRUKTUR BUKAN SEMULA JADI DI KAWASAN LAUTAN CETEK SABAH, MALAYSIA***

*Kajian ini mengkaji pengembangan 'macrofouling' pada bahan panel PVC yang digunakan di Karambunai, Sabah. Kajian ini dibuat di dua set paip PVC yang bersambung, bingkai dalam bentuk segitiga yang dilekatkan pada blok konkrit yang dipasang di dasar laut dan terus terapung secara menegak di bawah air. Set pertama (atas) bingkai diletakkan 2 m dari permukaan air manakala set kedua (bawah) melekat di kedalaman 8 m. Sebanyak 36 plat PVC eksperimen berukuran 20 cm x 27 cm diikat pada setiap tiga sisi dua set bingkai yang berbeza. Untuk menyiasat pengembangan 'macrofouling' secara bulanan, tiga panel diambil dari setiap sisi dari dua bingkai yang berbeza. Parameter pyhsico-kimia air laut seperti suhu air laut, kemasinan air laut, pH, kekeruhan, oksigen terlarut, kedalaman, kelajuan arus, arah arus dan pembiasan cahaya juga diambil, bersama dengan sampel air untuk analisis nutrien air seperti nitrat, amonia-nitrogen dan jumlah fosfat terlarut. Langkah-langkah ini dilakukan setiap 30 hari, sepanjang tempoh kajian selama 180 hari, dari April hingga September 2017. Hasilnya, sebanyak 13 spesies yang berbeza dikenal pasti berada di bahagian depan dan bahagian belakang panel pada jarak 2 m dan 8 m. Akibatnya, sebanyak 13 spesies macrofouling sessile dan 'motile' yang berlainan dijumpai di bahagian depan dan bahagian belakang plat pada 2 m dan 8 m. Untuk spesies sessile, dalam 90 hari pertama, Lyngbya sp. (alga) adalah spesies sessile yang paling banyak dengan peratusan litupan antara 70% hingga 90%. Namun, setelah 90 hari, Eudendrium sp. (hydroid) (hampir 80%) dan Amphibalanus amphirite (teritip) (hampir 50%) menggantikan Eudendrium sp. (hydroid) sebagai spesies yang paling dominan. Berdasarkan 'tiga way-ANOVA' pada pengaruh kedalaman, waktu kajian dan kedudukan panel, dengan peratusan litupan spesies sessile, pengiraan menunjukkan bahawa litupan spesies sessile ini dipengaruhi secara signifikan (P <0.05) oleh waktu kajian, kedalaman dan interaksi antara waktu kajian dan kedalaman. Bagi spesies makrofouling yang 'motile', tiga spesies dikenal pasti sebagai spesies dominan iaitu Perinereis sp. (ulat laut), Etisus dentatus (ketam) dan larva ikan dari keluarga Blenniidae. Berdasarkan 'two-way ANOVA' pada pengaruh kedalaman dan waktu kajian, dengan jumlah individu spesies dominan yang 'motile', pengiraan menunjukkan bahawa jumlah spesies dominan ini dipengaruhi secara signifikan (P <0.05) oleh waktu kajian dan kedalaman. Melalui analisis CCA, bilangan individu dan pertumbuhan di panel oleh makrofouling yang dominan ini dipengaruhi oleh pH, suhu, Kd, taburan hujan bulanan, kelajuan air lautan dan jangka masa panel berada di dalam air lautan. Walaupun eksperimen ini dipendekkan ke enam bulan, data yang diperoleh masih mencukupi untuk memberikan petunjuk mengenai jenis pengembangan dan penggantian komuniti makrofouling yang terjadi pada struktur buatan tersebut. Sebagai cadangan untuk eksperimen yang akan datang, adalah lebih baik untuk merangka kajian dengan memasang lebih banyak struktur bukan semula jadi di lebih banyak lokasi, untuk melihat lebih terperinci mengenai proses pengembangan dan penggantian komuniti makrofouling.*

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# LIST OF SYMBOLS AND UNITS

| | | |
|---|---|---|
| **%** | - | percentage |
| **°C** | - | degree Celsius |
| **g** | - | gram |
| **L** | - | litre |
| **m** | - | meter |
| **cm/s** | - | centimetre per second |
| **km** | - | kilometer |
| **mL** | - | millilitre |
| **mg/L** | - | milligram per liter |
| **abs** | - | absorbance |
| **ppt** | - | part per thousand |
| **<** | - | less than |
| **nm** | - | nanometer |
| **µmol m/2 s/1** | - | micromoles per meter squared per second |

# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| **ANOVA** | - | Analysis of variance |
| **GPS** | - | Global positioning system |
| **PAR** | - | Photosynthetically Active Radiation |
| **TDP** | - | Total Dissolved Phosphate |
| **$NH_3$-N** | - | Ammonia-Nitrogen |
| **$NO_3$-N** | - | Nitrate |

# LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

## 1.1 Chapter Overview

A brief introduction to the study was outlined and described in this chapter. The first part of the chapter (1.2) presents the background information on what is macrofouling are. The problem statement that leads to this study's experimental and analytical processes will be discussed in the second part of the chapter (1.3). The introduction chapter also includes the significance of study, objectives, and study hypothesis (1.3, 1.4, and 1.5).



## 1.2 Background Information of Study

Macrofouling is one of two types of biofoulings, which are caused by large marine organism, such as oyster, clam, mussels and barnacle. It can be categorised as either soft fouling or hard fouling (Callow & Callow, 2002; Alghamdi & Cordova, 2019). Soft fouling encompasses of algae and invertebrates, such as cyanobacteria, soft corals, sponges, anemones, tunicates and hydroids, while hard fouling comprises of invertebrates such as barnacles, mussels and tubeworms (Callow & Callow, 2002). Motile organisms such as crustacean and fish also can be considered as biofouling as they may live on the man-made structure (Gollasch, 2002; Madin, Chong & Basri, 2009). Essentially, biofoulers requires hard substrate to attach to as they depend to this structure for food source, stability, and supporting their growth. The primary habitat of this epibiotic organism is rocky reef, but due to aggressive development near coastal areas that degrades the natural habitat of the marine organism, it left these marine faunas with no choice but to attach themselves to these structures

(Railkin, 2005). Despite losing their primary habitat, these marine organisms still can adapt and thrive in living on to these artificial structures. This successful adaptation, however, is not yet been fully understand by biologist. Therefore, there is a need to conduct such study, as to provide prior knowledge on the macrofouling assemblages, their development rates and succession sequence in relation with submersion time and depth as well as to establish how environmental factors influence the development and succession pattern of the macrofouling community. With an establish prior knowledge on this topic, it would definitely help in the establishment of a better marine vessel management, as marine fouling is known to cause a lot of difficulty, especially in marine vessel maintenance (Alghamdi & Cordova, 2019).

## 1.3 Problem Statement

Sabah is among the state in Malaysia where various kinds of tourism facilities such as marina, jetty, hotel and many more tourism related development are rapidly developing along the coastal areas (Jakobsen et al., 2007), one of the areas that were targeted for development at the coastal of Sabah was Karambunai. The nature of Karambunai waters, that had a bottom area mostly covered with sand and silt with low level of net current movement (Hoque et al., 2009), suggest that it could be a strategic location to build a permanent structure such as harbour, water bungalow for tourism purposes, aquaculture farms and so on. However, this development are bound to encountered macrofouling problems, such as corrosion (Callow and Callow, 2002), physical damage, mechanical interference, competition and environmental modification while also affecting the facilities used for culture (Madin and Ching, 2015).

Present information pertaining on biofouling, in general, is not sufficient to provide complete information for a better management and mitigation measures of biofouling. Therefore, it creates barrier that prevent an effective management and encourage the use usage of antifouling paint that may contain copper as it has been used as antifouling agent for a long time (Callow & Callow, 2002). The use of copper can help to regulate the growth of algae, fungi and molluscs. Even though the method is effective, it cannot change the fact that copper is highly toxic to aquatic organism (Solomon, 2009).

This type of problem requires a background study on the biology and ecology of macrofouling community to provide better information and new ideas, so that in the future, it can be an input to a better management plan on handling this type of problem. To fulfil this purpose, a quantitative research study was constructed to observed biomass of test plates, percentage cover of each species that occupied on test plates, and development and succession process that occurred on the plates throughout time in Karambunai, Sabah.

## 1.4 Significance of Study

By classifying the marine organisms into the lowest possible taxa and factors that influence the biofouling growth such as light intensity, current and nutrient concentration (ammonia concentration, phosphorus concentration), it can help us to understand more on better the biology and ecology of the marine growth that will be growing on the artificial structures. The information gathered from this study not only allows further understanding on the factors influencing marine growth in this specific area but could potentially provide an insight to help predict and manage marine growth on marine structures in other parts of west coast of Sabah.



## 1.5 Objectives

This study aimed to elucidate the biology, ecology and factors influence the development of biofouling assemblages on artificial structure deployed in Karambunai. To achieve this, the following specific study were carried out:

I. To investigate the community assemblages, abundance, development rates and succession of macrofouling in relation to submersion time, depth strata and orientations.