UNIVERSITI PUTRA MALAYSIA

PHYSICAL AND CHEMICAL PROPERTIES OF CULTIVATION AREA THAT ENHANCE THE GROWTH OF Tegillarca granosa (LINNAEUS, 1758)

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By

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

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Chairman : Ferdaus @ Ferdius Mohamat Yusuff, PhD
Faculty : Environmental Studies

Due to the uncertain trend of cockle production in Malaysia, it causes this industry to be at stake. Continuous and sustainable cockle supply is imperative in order to fulfil public demand. To achieve a consistent and sustainable cockle production, solid understanding on the cockle habitat is highly imperative. Therefore it is imperative to identify and investigate the environmental condition that acts as supporting or limiting factors for cockle cultivation. The objectives of the study is to investigate the physico-chemical properties of sediment and water column at proposed cultivation area, to estimate the growth and survival rate of cockle at the proposed cultivation site, and lastly to established and select the best cultivation sites at Kongkong Laut by comparing with the reference area (Sungai Ayam). Screening of the physico-chemicals properties of water from the study sites was done from January until December 2015 and sediment was in December 2014 until March 2015. For water parameter analysis, negative correlation was found between water turbidity level and dissolved oxygen level ($r= -0.572$, $P<0.01$), the water pH level ($r= -0.611$, $P<0.01$) and positive correlation was found between the turbidity level and the water temperature ($r= 0.511$, $P<0.01$). This is because, higher turbidity level was due to high levels of total suspended solids within a water column, thus increase water temperatures and lead to decrease dissolved oxygen (DO) levels. A weak positive correlation was found between dissolved oxygen level with water pH level ($r= 0.436$, $P<0.01$), indicating factor that influence dissolved oxygen level within the Kongkong Laut estuary was not only due to temperature, but also due to the decomposition of organic substances as it also is a common process within an estuaries area. A significant positive correlation was found be-tween the level of nitrate concentration in water and phosphate concentration ($r= 0.778$, $P<0.01$), thus proves that both nitrate and phosphate concentration within the water might derived from the palm oil farm which located at the upper part of the estuaries. For sediment physico-chemical analysis, moderately negative correlation

was found between sedimentary organic matter and pH level ($r = -0.660$, $P<0.01$), indicating that the accumulation of organic matter in lower pH level within the sediment as high organic matter availability within the sediment lead to higher organic matter decomposition activity within the area. A significant positive correlation was found between sedimentary salinity and electroconductivity level ($r = 0.737$, $P<0.01$), signify that the concentration of salt that is trapped within the sediment might become the major influence that effects the level of sedimentary electroconductivity within Kongkong Laut estuaries. The determination of suitable cockle plot was mainly focused on two main factor. Based on the present of the mudflat and wild cockle within the sampling stations, KK1 (within Zone 1), KK7 (within Zone 2) and KK8 (within Zone was selected for further plot study. Among all of the three plot study, it is aware that Plot KK7 has the highest average cockle's growth increment (2.70 ± 0.32 mm per month), followed by KK8 (2.09 ± 0.27 mm per month) and KK1 (2.05 ± 0.16 mm per month) respectively. It is revealed that there was a significant positive moderate correlation between the salinity level and the cockle's growth rate ($p<0.05$, $r=0.65$), suggesting that salinity is might be the main reason for higher cockle's growth increment within Plot KK7. Among all of the three plot study, it is aware that Plot KK7 has the highest average cockle's survival rate (92 % per month) followed by KK8 (87%) and KK1 (73 % per month) respectively along the monitoring period from August to December 2015). The result suggested that turbidity might be the main reason that affecting cockles' survival within all of the plots as a high level of turbidity within a prolonged period of time have the potential to negatively affect cockle's survival within a habitat drastically. While, salinity was found to be the main reason that promotes cockle's growth within Kongkong Laut area as lower salinity condition leads to restrict cockle's feeding activity. As for that, KK7 was found to be the most optimal site for cockle cultivation activity in Kongkong Laut estuaries area due to highest cockle growth and survival rate that has been recorded. Comparison of water parameter between KK7 and reference site in Sungai Ayam shows that there was significant difference ($p<0.05$) in turbidity, salinity and dissolved oxygen, with Sungai Ayam shows a higher trend compare to KK7 station. While, comparison of sediment physicochemical parameter shows that there was significant difference ($p<0.05$) in all of the measured parameter (sand, silt, clay, organic matter, pH, salinity, electroconductivity). Although there were significant different of several parameters between reference site and KK7 station, the water and sediment physicochemical range of KK7 is still within the optimal range for cockle cultivation activity, thus explain highest cockle growth and survival rate of plot KK7 compare to plot KK1 and KK8.

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

SIFAT-SIFAT FIZIKAL DAN KIMIA DALAM KAWASAN PENTERNAKAN BAGI MENINGKATKAN PERTUMBUHAN *Tegillarca granosa* (LINNAEUS, 1758)

Oleh

AMIRUL AZUAN BIN MD JONI

Disember 2017

Pengerusi : Ferdaus @ Ferdius Mohamat Yusuff, PhD
Fakulti : Pengajian Alam Sekitar

Oleh kerana corak pengeluaran kerang tidak menentu di Malaysia, ianya menyebabkan industri penternakan kerang menjadi tidak stabil. Sumber kerang yang berterusan dan mampan adalah penting bagi memenuhi permintaan yang semakin meningkat. Disebabkan itu, pemahaman yang kukuh mengenai habitat kerang amat penting. Tujuan kajian ini adalah untuk mengenal pasti dan menyiasat keadaan alam sekitar yang bertindak sebagai faktor penyokong atau pembatas untuk penternakan kerang. Objektif terperinci kajian ini adalah; untuk mengkaji sifat-sifat fiziko-kimia sedimen dan air di kawasan penternakan yang dicadangkan, untuk menganggarkan kadar pertumbuhan dan peratus kerang yang hidup di tapak penternakan, dan akhirnya untuk menubuhkan dan memilih tapak pentenakan terbaik di Kongkong Laut dengan membandingkan dengan kawasan rujukan (Sungai Ayam). Persampelan dan pemeriksaan parameter air dari tapak kajian dilakukan dari Januari hingga Disember 2015, manakala persampelan sedimen pula dijalankan pada bulan Disember 2014 hingga Mac 2015. Untuk analisis parameter air, korelasi negatif didapati antara paras keruh air dan tahap oksigen terlarut ($r = -0.572$, $P < 0.01$), tahap pH air ($r = -0.611$, $P < 0.01$) dan korelasi positif didapati antara tahap kekeruhan dan tahap suhu air ($r = 0.511$, $P < 0.01$). Ini kerana, tahap kekeruhan yang lebih tinggi adalah disebabkan oleh pepejal terampai yang tinggi di dalam air, sekali gus meningkatkan suhu air dan menyebabkan penurunan tahap oksigen terlarut (DO). Korelasi positif yang lemah didapati berada di antara paras oksigen terlarut dengan paras pH air ($r = 0.436$, $P < 0.01$), menunjukkan antara faktor yang mempengaruhi paras oksigen terlarut di muara Kongkong Laut bukan sahaja disebabkan oleh suhu, tetapi juga disebabkan oleh penguraian bahan organik kerana ia juga merupakan proses yang lazim di dalam kawasan muara. Satu korelasi positif yang signifikan didapati di antara kepekatan nitrat dan fosfat di dalam air ($r = 0.778$, $P < 0.01$), membuktikan bahawa kepekatan nitrat dan fosfat di dalam air mungkin berasal dari ladang kelapa sawit yang terletak di bahagian atas muara sungai.

Untuk analisis fiziko-kimia di dalam sedimen, korelasi yang negatif di antara bahan organik dan tahap pH ($r = -0.660$, $P < 0.01$), menunjukkan bahawa pengumpulan bahan organik dalam paras pH yang lebih rendah dalam sedimen kerana ketersediaan bahan organik yang tinggi di dalam sedimen membawa kepada aktiviti penguraian organik yang lebih tinggi di dalam kawasan tersebut. Satu korelasi positif yang signifikan didapati antara tahap kemasinan sedimen dan tahap elektrokunduktivti ($r = 0.737$, $P < 0.01$), menandakan bahawa kepekatan garam yang terperangkap dalam sedimen mungkin menjadi pengaruh utama yang mempengaruhi tahap elektrokonductiviti sedimen di muara Kongkong Laut. Penentuan plot kerang yang sesuai tertumpu pada dua faktor utama. Berdasarkan pada keadaan lumpur dan kehadiran kerang liar dalam kalangan stesen pensampelan, plot KK1 (dalam Zone 1), KK7 (dalam Zon 2) dan KK8 (dalam Zon 3) telah dipilih sebagai tapak kajian plot untuk aktivti kajian yang selanjutnya. Di antara ketiga-tiga kajian plot, didapati bahawa plot KK7 mempunyai peningkatan pertumbuhan kerang purata tertinggi (2.70 ± 0.32 mm sebulan), diikuti oleh KK8 (2.09 ± 0.27 mm sebulan) dan KK1 (2.05 ± 0.16 mm sebulan). Korelasi sederhana yang positif antara tahap kemasinan dan kadar pertumbuhan kerang ($p < 0.05$, $r = 0.65$), menunjukkan bahawa tahap kemasinan mungkin menjadi sebab utama peningkatan pertumbuhan kerang yang lebih tinggi di dalam Plot KK7. Di antara ketiga-tiga kajian plot, didapati bahawa Plot KK7 mempunyai kadar kelangsungan hidup kerang purata tertinggi (92% sebulan) diikuti oleh KK8 (87%) dan KK1 (73% sebulan) sepanjang tempoh pemantauan dari Ogos hingga Disember 2015. Keputusan kajian menunjukkan bahawa tahap kekeruhan air mungkin menjadi sebab utama yang mempengaruhi kelangsungan hidup kerang dalam semua plot memandangkan tahap kekeruhan yang tinggi dalam tempoh yang berpanjangan mempunyai potensi untuk memberi kesan negatif terhadap kelangsungan hidup kerang di habitat secara menyeluruh. Oleh disebabkan ini, KK7 dijumpai sebagai tapak yang paling optimum untuk aktiviti penanaman kerang di kawasan Kongkong Laut kerana kadar pertumbuhan dan kelangsungan hidup kerang yang tinggi berbanding plot lain. Perbandingan antara parameter air di tapak KK7 dan tapak rujukan di Sungai Ayam menunjukkan terdapat perbezaan yang signifikan ($p < 0.05$) dalam kekeruhan, kemasinan dan oksigen terlarut, menunjukkan kawasan Sungai Ayam mempunyai corak parameter yang lebih tinggi berbanding dengan stesen KK7. Walaupun, perbandingan parameter fiziko-kimia di dalam sedimen menunjukkan bahawa terdapat perbezaan yang ketara ($p < 0.05$) dalam semua parameter yang diukur (pasir, lumpur, tanah liat, bahan organik, pH, tahap kemasinan, elektrokonduktiviti). Walaupun terdapat beberapa parameter yang mempunyai perbezaan yang ketara di antara tapak rujukan dan stesen KK7, pelbagai jenis fiziko-kimia air dan sedimen di tapak KK7 yang masih berada dalam julat optimum bagi aktiviti penternakan kerang. Ini secara tidak langsung menerangkan kadar pertumbuhan dan kelangsungan hidup kerang yang tertinggi di dalam plot KK7 berbanding dengan plot KK1 dan KK8.

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I certify that a Thesis Examination Committee has met on 19 December 2017 to conduct the final examination of Amirul Azuan bin Md Joni on his thesis entitled "Physical and Chemical Properties of Cultivation Area that Enhance the Growth of *Tegillarca granosa* (Linnaeus, 1758)" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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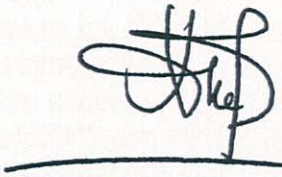

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This thesis was submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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This is to confirm that:

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Name of Member of Supervisory Committee: Dr. Khairul Nizam Mohamed

Signature: _____
Name of Member of Supervisory Committee: Professor Dr. Aziz Arshad

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LIST OF ABBREVIATIONS

EC	Electroconductivity
OM	Organic Matter
mv	Millivolt
ppt	Part per trillion
ms	Millisiemens
NTU	Nephlomatic turbidity unit
%	Percentage
meq/100g	Milliequivalents per 100 grams
mg/l	Milligram per liter
km^2	Square kilometer
km	Kilometer
m	Meter
cm	Centimeter
mm	Millimeter
et al.	And other

CHAPTER 1

INTRODUCTION

General

The blood cockle *Tegillarca granosa* (formerly known as *Anadara granosa*) is one of the major aquaculture species in Malaysia and dominates 93% of the total shellfish species production (DOFM, 2013). Malaysia is also one of the major producers of adult cockle in Asia with the biggest market in Thailand and Singapore (FAO, 2012). Cockle farming, which once only been practised by certain traditional farmers, became one of the highly marketed components in shellfish industry since 1980. Nowadays, cockle farming area covers 10,000 acres along the west coast of Peninsular Malaysia, which approximately involves 1,000 farmers (DOFM, 2013). Generally, Pulau Pinang, Perak, Selangor and Johor play a significant role in producing adult cockle and in conserving the natural habitat of cockle spat. Due to the gazettement of the cockle farming areas along its west coast, Selangor has been a major producer of adult cockle since 2007 (Pahri *et al*., 2016).

However, since 2010, there was an uncertain trend of cockle production in Malaysia, thus, causes this industry to be at stake (DOFM, 2016). As for that a continuous and sustainable cockle supply is imperative in order to fulfil public demand. Reduction of several cultivations in Malaysia such as in Pulau Pinang and Kuala Selangor due to increase in development within these areas is one of the reasons that lead to decreasing cockle supply in our country. Although there were recent reports state that the decreasing cockle seed at Sungai Buloh may due to high concentration of ammonia that originates from farm and factories (Ramli *et al*., 2013), the real causative factors for other cockle's cultivation area is still unclear. The reclamation activity as happened along the Mukim Lekir coastline at Perak in 1997 caused a massive loss of natural cockle spatfall area, hence causes negative impact towards cockle's production in the subsequent year (Ramli, 2005).

Not only that, massive seed smuggling to Thailand is also one the major reasons that cause a decrease in seed supply from since the last 20 years (Izura and Hooi, 2008). Due to these circumstances, in order to achieve a consistent and sustainable cockle production, we must first have a deep understanding about the cockle's habitat, ecology and their suitable sur-rounding before proceeding with any further research as it is crucial to understand the basic knowledge. Most of the current study on the Malaysian's blood cockle only emphasize on their culture and biology (Broom, 1985; Pathansali and Song, 1958; Tookwinas, 1983) but less information about the ecology and the physicochemical substances in the environment that may play an important role towards their abundance and availability. Therefore, study on the effect of environmental factors towards cockle's growth and survival is required in order to gain a better understanding on the cockle's habitat and ecology.

1.1 Problem Statement

The blood cockle, *Tegillarca granosa* is Malaysia's premier aquaculture product in volume and value. During the prime time of its aquaculture activity in 1980's, cockle's farmers not only have a good living, they also generate many other jobs through seed collection, harvesting and marketing (Angel, 1987). During the peak of the cockle farming activity, Malaysia produces 100,000 tonnes of cockles for both local consumption and export (Spykerman, 2016). However, there was a major concern on the reduction of cockle production within these recent years as it is only16, 000 tonnes were recorded during 2015 (DOFM, 2016). Due to this circumstance, it is an urgent need for preventative or procurement measure towards these problems that had been affected in Malaysia nationwide since 2010.

Reduction of cockle cultivation site was expected to be the major factor that leads towards a mass reduction of cockle production within these recent years. This circumstance occurred due to the habitat degradation within cockle farming area that may cause from the anthropogenic source, thus lead towards cockle's mortality (Izura and Hooi, 2008; Ramli *et al*., 2013). This, however, was only based on a limited study that only focuses on a certain region. Thus, it is not representing mass cockle mortality event within the cultivation area nationwide.

One of the major research challenges lies on the various environmental factors that need to be focused. This is because the real causative factors which lead towards cockle's mass mortality event is still unclear. Although several researches have been done by the local authorities, there is still no concrete study regarding this issue. Most of the findings were still inconclusive and were focused only on one single factor, without taking account on other co-factor that might involve during the process. Therefore, deeper understanding on cockle's habitat is crucial in order to minimize cockle loss in the future. In addition, profound knowledge on the cultivation site might help to established new habitat for cock-le cultivation area including river and estuaries. This is important in selecting the ideal site for sustainable of cockle farming activities, and hence sustainable cockle production in the future. Hence in this study, Kongkong Laut estuaries area was selected as the study site due to the presence of natural wild cockles, while Sungai Ayam which located at Batu Pahat, Johor was selected as the reference site due to its status as commercial cockle farming area.

1.2 Significant of Study

There was high demand of cockles from local and foreign country but short amount of supply. Furthermore, the unpredictable trend of cockle production within these recent years cause cockle farming industry to be at stake. Therefore, another effective alternative way must be employed in order to have a sustainable cockle supply in the future. This study was expected to provide a substantial information regarding the best cockle's habitat and its surrounding, which enables us to have a profound understanding about biology and ecology of cockle. This knowledge will act as a benchmark as

it will help future researcher to have better planning regarding on cockle's research. Thus, with continuous study in the future, a better management for cockle farming can perhaps be employed, and eventually improve Malaysian's cockle production in the future.

1.3 Research Aim and Objective

This aim of this study is to attempt, identify and investigate the environmental condition that act as supporting or limiting factors for cockle cultivation. To achieve this, specific objectives as shown below have to be completed:

1) To investigate the physico-chemical properties of sediment and water column at proposed cultivation area.
2) To estimate the growth and survival rate of cockle at the proposed cultivation site.
3) To established and select the best cultivation sites at Kongkong Laut by comparing with the reference area (Sungai Ayam).

1.4 Research Questions

There were a few questions that need to be answer in this study:

1) What is the physical and chemical properties of sediment water column within the cultivation area?
2) What is the growth and survival rate of cockle within the proposed cultivation site?
3) Can the best cockle's cultivation site at Kongkong Laut be established?

1.5 Framework of study

The study began with the sampling activity at both Kongkong Laut (study site) and Sungai Ayam area (reference site). Sediment samples will be collected as well as water in-situ parameter data. The samples were then being analysed in order to gain the physico-chemi-cal characteristics data for both study and reference site. Statistical approach will be utilized to the raw data to determine physical and chemical properties of sediment and water column at the study site.

To determine cockle's growth performance and survival rate, the cockle plot will be set up within each of the selected locations before the cockle samples from the reference site been translocated into each of the study plots. Data for cockle's survival and

growth rate was done on monthly basis, with another particular concern of water in-situ parameter.

Finally, by utilizing the data of physicochemical properties, together with the data set of cockle growth and survival, the pattern of the most suitable cockle cultivation site can be determined and thus the best area for cockle habitat within the study site can establish. Later, physico-chemical properties of water and sediment within the established cockle culture area will be compared with the reference area at Sungai Ayam, Batu Pahat, Johor and been discussed further. That was basically an overview of what occurring within this study in order to finally determine the environmental condition that acts as supporting or limiting factors for cockle cultivation. Further explanation of methodology were great details in Chapter 3. Figure 1.1 shows the overview done in this study.

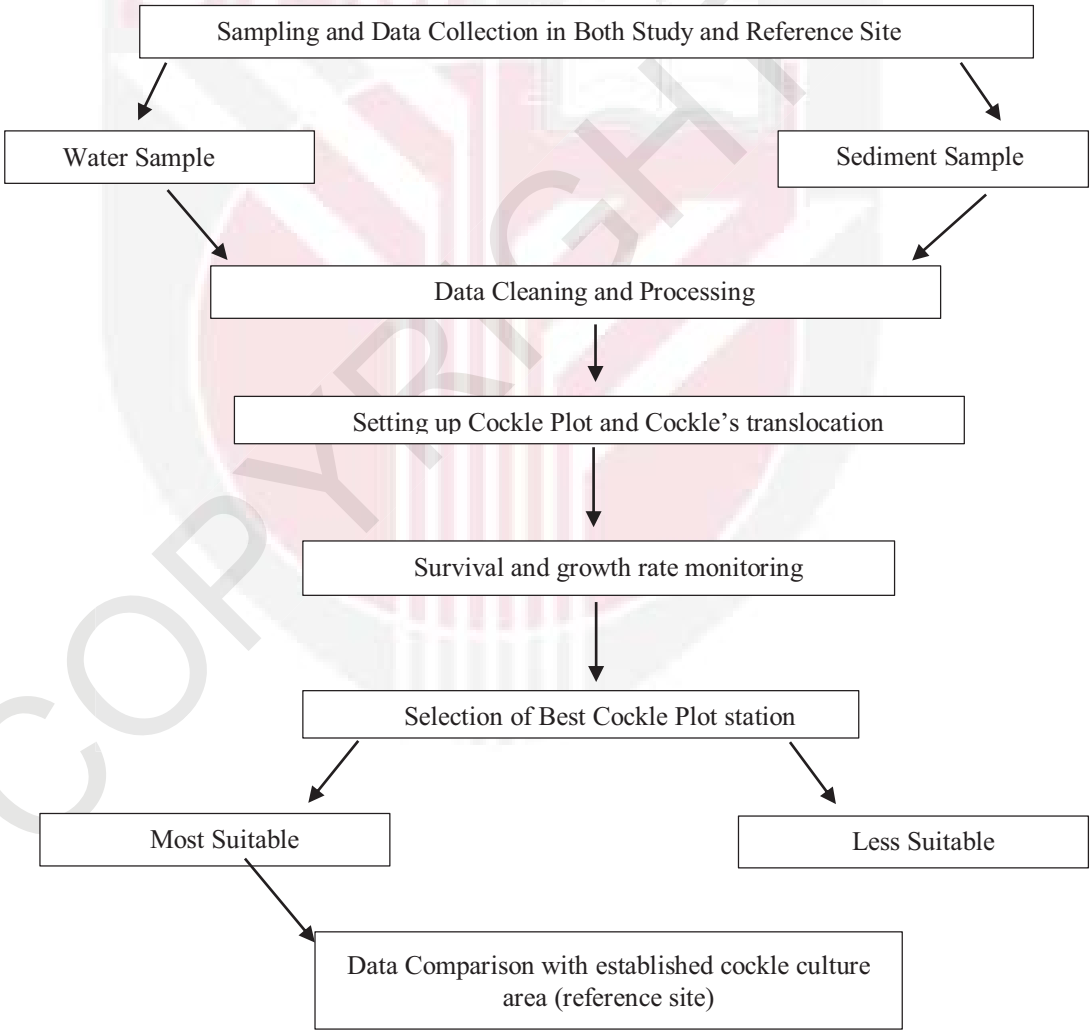

Figure 1.1 : Overview of phases to established new cockle cultivation site within study area

1.6 Thesis Organization

This thesis divided into five main chapters. Chapter one gives the brief view of this study, research problems, the objectives and significant of study and the general framework used in this study. Chapter two elaborate on the past literature review regarding several relevant topics and also past research that almost similar to this study. Chapter three discuss the methodology for this study in great detail and elaboration while chapter four focuses on the result and detail discussion and elaboration from the analysis based on the objectives. Lastly, chapter five is the conclusion part where the summary and recommendations for future study being discussed and suggested.

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