

**REMOVAL OF TOTAL NITROGEN AND PHOSPHORUS IN
SHRIMP FARM EFFLUENT
BY BURNED BLOOD COCKLE SHELL**

The seal of Mahidol University is a circular emblem. It features a central blue circle containing a golden Thai-style crown (Mueang) with a flame-like base. The crown is flanked by two golden lions. The entire central design is set against a light blue background. Surrounding this central circle is a wider, light yellow ring containing Thai script in a circular arrangement. The text is in a stylized font, likely representing the university's name in Thai.

MOTHINEE AOPREEYA

**A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE
(APPROPRIATE TECHNOLOGY FOR RESOURCES
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FACULTY OF GRADUATE STUDIES
MAHIDOL UNIVERSITY**

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Thesis
Entitled

**REMOVAL OF TOTAL NITROGEN AND PHOSPHORUS IN SHRIMP
FARM EFFLUENT BY BURNED BLOOD COCKLE SHELL**



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REMOVAL OF TOTAL NITROGEN AND PHOSPHORUS IN SHRIMP FARM EFFLUENT BY BURNED BLOOD COCKLE SHELL

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ABSTRACT

This research was carried out to investigate the efficiency of removal of total nitrogen and phosphorus from shrimp farm effluent by burned blood cockle shells. The removal of total nitrogen and phosphorus varied with blood cockle shell's size and flow rate. The characteristics of blood cockle shells were studied by comparing burned blood cockle shells, natural blood cockle shells and activated charcoal

The results indicated that the burned blood cockle shells at 0.85-2.0 millimeters had a removal efficiency of total nitrogen and phosphorus at 86.66% and 77.53%, respectively. The best flow rate was 300 ml./hour. Burned blood cockle shell, natural blood cockle shell and activated charcoal were all absorbent. Burned blood cockle shell was the most effective in phosphorus and total nitrogen removal. Equilibrium modeling of the adsorption isotherm was more fitted to the Langmuir model than Freundlich model. The characteristics of burned blood cockle shells by Gas Sorption Analyzer by Brunauer, Emmett and Teller method (BET) indicated they had higher BET surface area and bigger average pore size than natural blood cockle shells.

KEY WORDS : NITROGEN / PHOSPHORUS / EFFLUENT / SHRIMP / BURNED BLOOD COCKLE SHELL

91 pp.

การบำบัดไนโตรเจนรวม และฟอสฟอรัสในน้ำทิ้งจากนาุ้งโดยใช้เปลือกหอยแครงเผา
(REMOVAL OF TOTAL NITROGEN AND PHOSPHORUS IN THE SHRIMP
FARM EFFLUENT BY BURNED BLOOD COCKLE SHELL)

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วท.ม.(เทคโนโลยีที่เหมาะสมเพื่อการพัฒนาทรัพยากรและสิ่งแวดล้อม)

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บทคัดย่อ

งานวิจัยนี้เป็นการศึกษาประสิทธิภาพการลดปริมาณไนโตรเจนรวมและฟอสฟอรัสในน้ำทิ้งจากฟาร์มกุ้ง โดยใช้เปลือกหอยแครงเผา ปัจจัยที่ใช้ในการศึกษา คือ ขนาดของเปลือกหอยแครง ซึ่งมี 3 ขนาด อัตราการไหลของน้ำทิ้งที่ต่างกัน นอกจากนั้นทำการวิเคราะห์คุณลักษณะของเปลือกหอยแครง และเปรียบเทียบประสิทธิภาพการลดปริมาณไนโตรเจนรวมและฟอสฟอรัสระหว่างเปลือกหอยแครงเผา เปลือกหอยแครงสด และถ่านกัมมันต์

จากผลการศึกษา พบว่า เปลือกหอยแครงเผาขนาด 0.85 – 2.0 มม. เป็นขนาดที่เหมาะสม โดยมีประสิทธิภาพการลดปริมาณไนโตรเจนรวมและฟอสฟอรัส คือ 86.66 % และ 77.53 % ตามลำดับ ส่วนอัตราการไหลนั้น พบว่า ที่อัตราการไหลที่ต่ำสุดมีประสิทธิภาพในการลดไนโตรเจนรวมและฟอสฟอรัสได้ดี ซึ่งได้แก่ 300 มล.ต่อชม. และเมื่อศึกษาเปรียบเทียบระหว่างเปลือกหอยแครงเผา เปลือกหอยแครงสด และถ่านกัมมันต์ พบว่า เปลือกหอยแครงเผามีประสิทธิภาพการลดปริมาณไนโตรเจนรวมและฟอสฟอรัสที่ดีกว่าเปลือกหอยแครงสด แต่ไม่สามารถสรุปผลการศึกษาของถ่านกัมมันต์ได้เนื่องจากการทดลองล้มเหลว ในส่วนของแบบจำลองไอโซเทอม การลดปริมาณไนโตรเจนรวมและฟอสฟอรัสโดยใช้เปลือกหอยแครงเผา มีความสัมพันธ์กับแบบจำลองของ Langmuir มากกว่าแบบจำลองของ Freundlich และจากการศึกษาเรื่องคุณลักษณะของเปลือกหอยแครงโดยวิธี Gas Sorption Analyzer by Bunauer, Emmett and Teller method (BET) พบว่า เปลือกหอยแครงเผามีค่าพื้นที่ผิวจำเพาะ และค่าเฉลี่ยขนาดรูพรุน มากกว่าเปลือกหอยแครงสด

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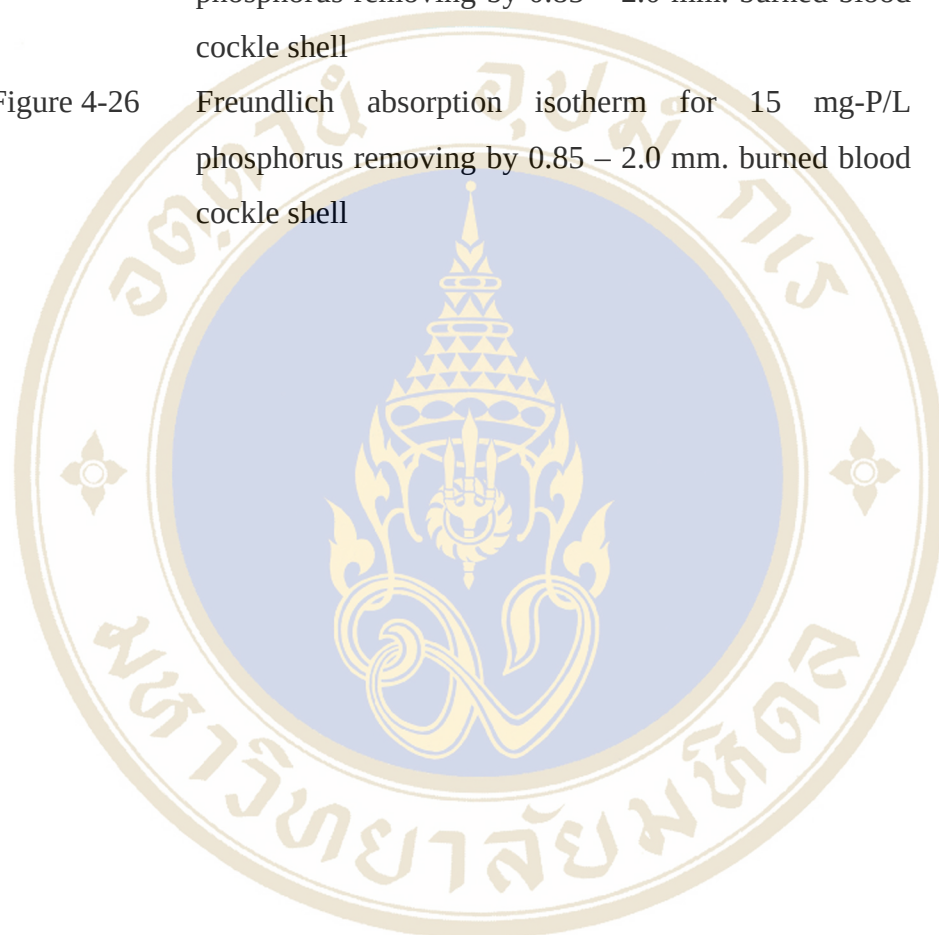
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CHAPTER I

INTRODUCTION

1.1 State of Problem

The problem of effluent from aquacultural farm is the another important issue that affect the natural water since there are high level of nutrient in effluent that drained from aquacultural farm such as nitrogen, ammonia, and phosphorus. When these nutrients has released to water, it will make that water is enrich of nutrient. The dramatically in increasing of nutrients will make Eutrophication occur which initiates plankton bloom. Especially, nitrate and phosphate are the nutrients that cause Eutrophication while plankton bloom causes the lack of oxygen in the water in the time that there is no rotation or exchange of mass (1) and the occurrence of red water condition or red tide which much more affect the environment and people who lives in the coastal area, or poisonous to the living organism, or accumulate in shells and transfer the toxic to shell consumers. Thus, it depends on the type of plankton (2), today, there is an announcement from Natural Resource and Environment Ministry about the standard of release effluent from coastal aquaculture for the purpose of control the quality of water before release to the water. Therefore, every aquacultural farm has to have the remedy process before it releases to the water.

Table 1-1 The standard of effluent from coastal aquaculture

Parameter	Unit	Maximum
pH	-	6.5-9.0
BOD	mg./l.	20
Suspended solids	mg./l.	70
Ammonia	mg-N /l	1.1
Phosphorus	mg-P/l	0.4
Hidrogensulfide	mg./l.	0.01
Total nitrogen	mg-N/l	4.0

Source: Department of pollution control, 2001 (3)

There are many methods in the removal process of effluent. The popular method is a biological techniques. But for this case study, it uses the absorption method in the removal process and the medium of the study is blood cockle shells. Using of natural material is a another alternative that save cost in the removal process and is also make the usefulness of the materials that we don't need. Because of nowadays, there is the increasing of a number of blood cockle consumers which led to increasing in a number of rear cockle. A number of blood cockle in 2005 (4) was 58832 tons, therefore, after the consumption of blood cockle, shells become an abundant materials which easy to find in some area at cheap price and safety to use as a medium in absorption. Moreover, the main element of cockle shell is calcium carbonate (CaCO_3) as same as oyster shell which can absorb phosphorus (5). In this study, the experiment use blood cockle shells in order to removal of total nitrogen and phosphorus which are in the effluent from Shrimp farms.

1.2 Objectives

1. To study burned blood cockle shell adsorbent for the removal of total nitrogen and phosphorus in effluent from shrimp farm

2. To study the optimum condition for the removal of total nitrogen and phosphorus in effluent from shrimp farm using burned blood cockle shell in different factor such as flow rate and particle size

3. To compare the absorptive efficiency of total nitrogen and phosphorus using burned blood cockle shell and natural blood cockle shell and activated charcoal in optimal flow rate

1.3 Hypothesis

1. Burned blood cockle shell is adsorbent for the removal of total nitrogen and phosphorus in effluent from shrimp farm

2. There are differences on the efficiency of burned blood cockle shell, natural blood cockle shell and activated charcoal for the removal of total nitrogen and phosphorus in effluent from shrimp farm

1.4 Scope of study

The removal of total nitrogen and phosphorus in effluent from shrimp farm using burned blood cockle shell in different factor such as flow rate and particle size

- Use of burned blood cockle shell which burning at 750°C (5). Particle size is 0.85-2.0 mm., 0.3-0.35mm. and >2.0mm.
- Effluent from shrimp farm
- The process is column experiment design
- Contact time is 8 hours.(7)
- Size of column is Ø 75mm. High 1.0 m.(8)
- Height of absorbents is 60cm.(8)
- This experiment is not renew absorbents and use new absorbents every time. Keep out effluent from process when end of time

1.5 Variables of study

The removal of total nitrogen and phosphorus in effluent from shrimp farm using burned blood cockle shell in different factor such as flow rate and particle size

Independent Variables is

- Particle size of burned blood cockle shell
- Flow rate of effluent use
- Concentration of total nitrogen and phosphorus in effluent from shrimp farm

Control Variables is

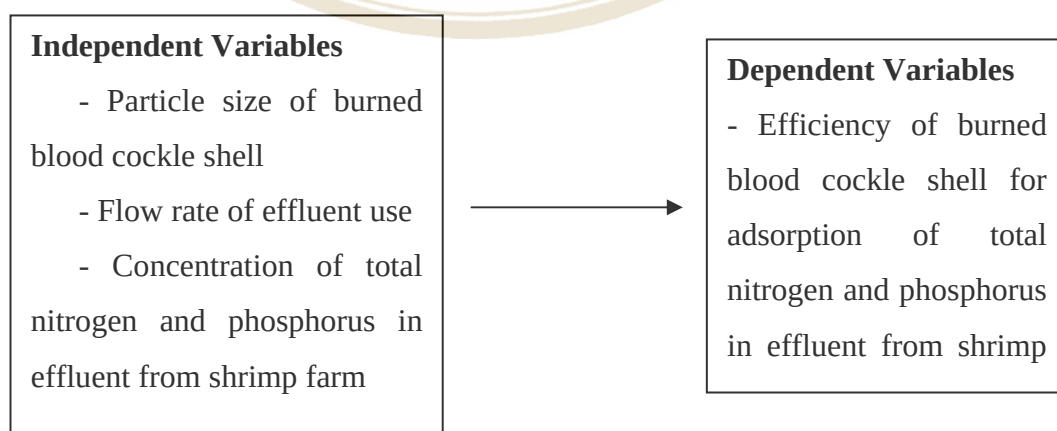
- Contact time
- High of absorbents (burned blood cockle shell)

Dependent Variables is

- Efficiency of burned blood cockle shell for adsorption of total nitrogen and phosphorus in effluent from shrimp farm

1.6 Conceptual Framework

The removal of total nitrogen and phosphorus in effluent from shrimp farm using burned blood cockle shell in different factor such as flow rate and particle size



1.7 Definition

Effluent : discharged water from shrimp farm which usually contaminated with organic sludge, food waste and plankton (6)

1.8 Expected Results

1. Know optimum condition for adsorption of total nitrogen and phosphorus in effluent from shrimp farm and use optimum condition for adsorption of total nitrogen and phosphorus in effluent from real shrimp farm
2. Know efficiency of absorbents to be develop and use in another aquaculture farm
3. Decreasing total Nitrogen and Phosphorus in effluent for prevent Eutrophication
4. Utilization of waste blood cockle shell

CHAPTER II

LITERATURE REVIEW

2.1 The characteristics of effluent from shrimp farm

Effluent from shrimp pond is the water that comes from variety of activities of shrimp pond and drained it into the natural water sources by some characters of water will be change in both physical and biological which will affect the natural environment (9). Normally, effluent from shrimp keeping is consisted of two components which are dregs or puddle part, and another part is the water that come from water sluice method which consist of organic substance, plankton, toxin, metal, medication, medicals, and etc. The characteristics of effluent from the doing of shrimp farm are the followings (10):

1. Salinity: The degree of salinity of effluent from the shrimp farm depends on the climates. In the rainy season, the degree of salinity is relatively low due to the dilution by rain water and it will be increased in the winter period due to the water evaporate. The salinity of effluent from shrimp farm which is left into the Kung Kra Ben bay is in between 1 - 40 ppt. which it would be from 1 - 24 ppt. during the rainy season and it would be increased during the winter and the highest degree of 30 - 40 ppt.(11) The degree of salinity in the shrimp farm area is about 18 – 30 ppt. in Rayong Province (12).

2. pH: According to the study of the quality of water in shrimp pond with the developed style which there are density differences (13), found that the pH value of water from shrimp keeping in difference density are very similarity which in between 6.5 – 9.2 and the average is between 7.9 – 8.3. And the pH value in the drain-water canal is as similarity as in the shrimp pond and also similar to the study of the quality

of water in the shrimp field of Thailand during 5 months which there is the pH value of 7.5 – 8.9 (14).

3. Dissolved Oxygen: The amount of living organism and plankton are affecting the amount of oxygen. Planktons use photosynthesis process in order to produce the oxygen during daytime. The amount of oxygen will be increasing during daytime while there is no photosynthesis process at night or dawn which leads the oxygen value to be reducing until there is not enough oxygen for the living things in the shrimp pond. According to the study of dissolved oxygen of the water that left into the Kung Kra Ben bay (11), found that the agriculturists will sluice from shrimp pond during the ebb tide which leads the quantity of water in the water source to be reducing during the ebb tide and the value is in between 0.4 – 7.0 milligrams per liter while the value is in between 4.3 – 8.0 milligrams per liter during the flood tide. The value of dissolved oxygen in the shrimp pond in the developed style (13) and the variation value are in between 2.8 – 12.8 milligrams per liter which 4.9 – 7.4 milligrams per liter in average (12). During the period of lobstering and mire injection in order to wash the pond are the factors that lead to low dissolved oxygen value. Besides that, the dissolved oxygen value is also low during the summer due to the reduction in dissolve ability of oxygen while the need of microbe for digestion is increasing.

4. BOD: According to the study of effluent from shrimp pond with developed style in different density conditions (13), found that BOD value is in the 0.3 – 34.6 milligrams per liter and the average is 5.6 – 14.2 milligrams per liter which the BOD value of the pond with high density is higher than the pond with low density. BOD has direct relationship with quantity and type of food for shrimp keeping. There will be food left behind if feed too much foods and shrimps will defecate more which lead to has higher BOD. BOD value in the effluent which come from the shrimp field and left to Kung Kra Ben bay during the ebb tide is 1.87 – 7.17 milligrams per liter while 0.30 – 4.52 milligrams per liter during the flood tide. BOD value in the shrimp pond is tending to be increasing follow to the density and keeping periods and it will be increasing when doing the mire injection for washing pond (11).

5. Ammonia: Mostly, generated from waste products from shrimps and organic substance dissolvable in the pond. Almost foods that use to feed shrimps are protein which is the one that generated waste products in the pond. When we feed too much food, the foods that left behind will dissolved water and are also digested and become ammonia by microbes. Ammonia – Nitrogen value of effluent that left into Kung Kra Ben bay during the ebb tide is 0 – 4.36 milligrams per liter and 0 – 4.82 milligrams per liter during the flood tide (11). Ammonia – Nitrogen value of effluent from shrimp pond has different density. The pond with high density has higher Ammonia – Nitrogen value which is 19.67 kg. per pond with 2 rai, and the pond with lower density has lower value which is only 2.8 kg. per pond with 2 rai (14), and there is 0.2 – 0.32 milligrams per liter in the water in natural canal in the areas that there are shrimp keeping exist in Rayong Province (12).

6. Nitrite: It generated from protein digestion by bacteria which protein will transform to ammonia, then, ammonia will transform to nitrite and nitrate by nitrification process. The amount of nitrite – nitrogen from shrimp pond that left into Kung Kra Ben bay (11) during the ebb tide is 0 – 0.187 milligrams per liter while 0 – 0.101 milligrams per liter during the flood tide. The amount of nitrite would be more or less depends on many factors. According to the study of water quality from the shrimp pond in different density conditions, found that nitrite – nitrogen value is 0 – 0.909 milligrams per liter. The pond with higher density has higher nitrite – nitrogen value due to the collection of organic substances and more digested than the pond with lower density. Besides that, the periods of keeping are also impact the amount of nitrite – nitrogen. The amount of nitrite – nitrogen will be increasing follow the keeping periods and it will be a lot in the last month of keeping, shrimp catching period, and mire injection for washing pond. Dissolved oxygen is also affecting to the amount of nitrite in the condition that lag of oxygen, especially, at night which lead to incomplete oxidation process from nitrite to nitrate and also generate the denitrification process which transform nitrate to be nitrite.

7. Nitrate – Nitrogen: The study about the amount of nitrate – nitrite from shrimp pond that left into Kung Kra Ben bay (11) during the ebb tide is 0 – 0.125

milligrams per liter while 0 – 0.410 milligrams per liter during in flood tide. As the studying the amount of pollutant that left from shrimp pond with developed style in the size of 2 rai. The pond with high density has nitrate – nitrogen 0.43 kg. per pond which higher than the pond with lower density which has only 0.19 per pond (14)

8. Orthophosphate: The amount of orthophosphate from shrimp pond is 0.027 – 3.405 milligrams per liter and the average is 0.027 – 0.31 milligrams per liter and it tend to be increasing follow the density of culture (13). Food scraps and shrimps' excreta are the source of phosphate in the shrimp pond (15). For the studying about the effluent from the doing of shrimp field that left into Kung Kra Ben bay, there are the amount of phosphate 0 – 0.081 milligrams per liter during the ebb tide and 0 – 0.27 milligrams per liter during flood tide (11).

2.2 The affects from the shrimp culture in the coast area

Nowadays, shrimp culture is also another source of pollutions which generates impact to the environments due to the inappropriate of the avoidance system of drainage from the farm such as feeding is not fit with the aquatic animals, using of medicals and chemicals in order to protect and remedy and also including supplementary foods feeding which lead to high amount of nutrient in the shrimp pond. From the study of Tookwinas (16), found that shrimps apply nitrogen (N) and phosphorus (P) from all shrimp's foods only 22.5 and 14.0 percent respectively and for the remaining of 77.5 percent of nitrogen and 86.0 percent of phosphorus will dissolve to the water or become the food scraps and will be the collection of waste products at the pond bottom. These waste products would increase the amount of organic substance in natural water sources which is the way to increase nutrients to the water source and lead to increase the number of plankton dramatically and also generate the Eutrophication and plankton bloom which lead to the lag of oxygen in the water source. From the studying of Tunvilai (14) about the amount of pollution that left from the shrimp pond in the developed style, confirm that there are much pollution are released from shrimp keeping in the time that close to catching period which most of them are aquatic plant's foods and it is the nutrient that generate the

abundant condition in the water sources while the study of Kwei (17), found that in the production of 1 ton of shrimp by specifying the different exchange rate will produce the important compounds such as organic, nitrogen, and phosphorus in different rates, for example, there are 875 kg. of organic elements which are food scraps, 56 kg. of nitrogen, and 21 kg. of phosphorus at the exchange rate of 1.5.

From the study of Pollution Control Department (18), found that the quality of effluent from shrimp pond in Songkhra and Nakornsrithummaraj Provinces have pH value of 7.40 – 8.40, the degree of salinity is 13 - 27 ppt, the amount of ammonia is 0.077 – 4.281 milligrams nitrogen per liter, the sum of the amount of nitrogen is 3.974 – 11.832 milligrams nitrogen per liter, the sum of the amount of phosphorus is 0.186 – 0.491 milligrams phosphorus per liter, the amount of hydrogen sulfide is 0.005 – 0.084 milligrams per liter, BOD₅ value is 12.1 – 27.4 milligrams per liter, and the amount of suspended solid that can precipitate is 164.0 – 736.0 (milligrams per liter) which some of the discovered nutrients have higher value than the standard value of effluent from the coast aquatic animal aquarium.

2.3 Adsorption Process

Adsorption process is the process that associated with the increase in the intensity by force on the molecules' surface or within the molecules themselves, due to molecules are concentrated on the surface of the activated carbon, between two molecules in different stages. For examples, the adsorption between liquid-gas, liquid-liquid, and liquid-solid substances. If the 2 stages are liquid-solid, there will be an imbalance of the molecules' interaction at the molecules' surface. The solid substance that can adsorb the liquid's molecule is called the 'Adsorbent' and the molecules of liquid that are attached on the solid molecules' surface are called 'Adsorbate'. The interaction between molecules occur in 3 sequential stages (19) shown in figure 2-1

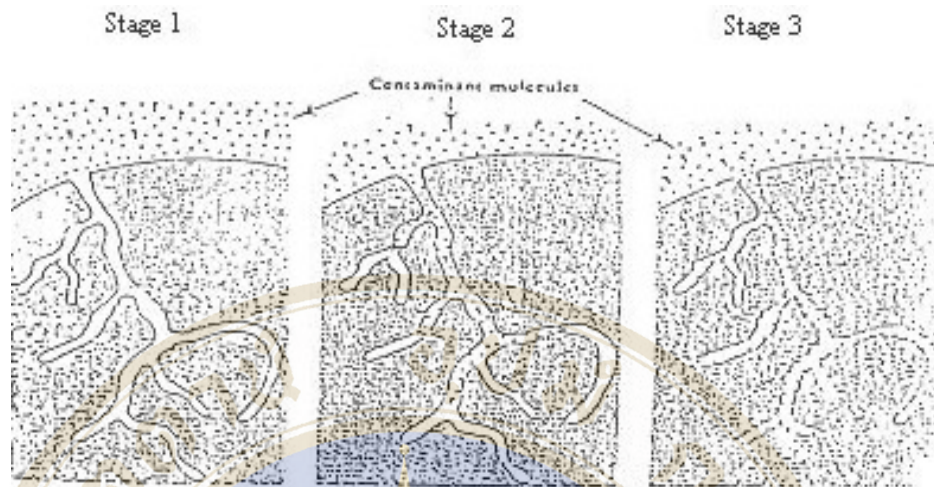


Figure 2-1: the mechanisms of molecules' interaction.

Stage 1: the dirty molecules in the water will migrate and be encircled outside the adsorbent.

Stage 2: the dirty molecules will diffuse (by the diffusion process) to the free space of the adsorbent's outer shell.

Stage 3: The interaction between the dirty molecules and the adsorbent's surface takes place.

2.3.1 Type of absorbing

Absorbing can distribute in to three kinds (16)

1. Physical Adsorption

Physical adsorption is related to the pressure within the molecule, and the force which make sticking status between of absorbed substance and molecule is quite week. And this force is the same force for the gravity between the molecule and Vander Waals Force. The adsorbed molecule still remain its chemistry as before, neither it will stay position solid mind, liquid, or gas

2. Chemical Adsorption

Chemical Adsorption will related to chemical bond of adsorbed molecule and the surface of absorbs molecule. This absorbing depend on the chemical reaction which prevent absorb molecule from any movement at the surface.

Sometime, Chemistry absorbing have to use energy as well, called activated adsorption, which cause absorbing force even grater than physics absorbing.

3. Exchange Adsorption

Exchange Adsorption is an absorbing between a substance that was absorbed with a substance absorbs at the surface, by sucking with electricity attraction, on the surface for Ion exchanges, can stay in this group, make the substance ion sticks at the surface that has opposite ion, high ion, such as Trivalent Ion will suck stick well more than low ion, and ion that have small-sized suck stick better.

2.3.2 Type of adsorption (19)

Substance absorbs to have various kinds, might divide get three a kind, as follows;

1. Organic compound such clay, magnesium, Bone char, Activated Silica. Surface area particularly is around 50-200 square meters. 1 disadvantage is it can catch only few molecule and colloid

2. Activated charcoal is better than other organic because of the surface area particular is around 600-1,000 square meters per gram. Used Activated charcoal can regenerate and reused but the disadvantage for the regenerate is it has to burn at high temperature which cost a lot of money and some of carbon will be lost and become powdery, dust then we can't use it.

3. Synthetic organic which can suck other item which has opposite Ion which can cause stacking such as a substance exchanges kind special ion that create by human for eradicate organic all substance called Macro porous Resin or Adsorbent Resin such as Styrene Divinylbenzend (SDVB) Resin and Phenol-formaldehyde (FF) Resin, there is skin area particularly about 300-500 a square meter per gram which lower than Activated Carbon but it is also have advantage that it can easy recover and a substance that use to recover the state often cheap such as salt.

2.3.3 Factors Affecting Adsorptions (15)

1. Nature of the Adsorptions

- Surface Area and Pore Structure

Surface area is one factor that can affect to molecule ability for adsorption which means the ability for adsorption will be higher if they have more molecule surface area however, molecule surface area is can not explain the ability of adsorption. Pore structure is also help surface area have more ability for adsorptions because if the molecule could get through to the pore the ability of adsorptions will be better but if molecule can not get through to the pore the ability of adsorption will be less.

- Particle Size

In case that if Molecule do not have pore then the surface area will increase then when the size is smaller the ability of adsorption will be increase but if the Molecule has many pore the surface area which used for adsorption will be inside of pore, then this case the adsorption ability will not depend on size.

2. Nature of the Adsorbate

- The ability in the dissolution.

The high ability in the dissolution will indicate reaction of solvent and solute which will down the spreading absorbing because before adsorption process will have to bond break of solvent and solute.

- Molecule weight and size molecule

Molecule weight and size molecule will affect to adsorption ability when molecule weight and size molecule increase the ability adsorption will be increase as well such as if molecule of adsorption is an organic, if atom increased the adsorption ability will increase as well because the molecule weight is decrease adsorption ability.

- Polar of Molecule

The adsorption ability will decrease when polarity status is higher because the higher polarity will increase dissolve ability.

3. Effect of Temperature, when the temperature is adsorption ability will higher but the ability of stuck will decrease because the adsorption is an exothermic reaction.

2.3.4 Adsorption equilibrium

Adsorption process will be continuing occur by the item will adsorb and desorb at the same time which will make adsorption equilibrium. At this point concentration of adsorption in the water is equal to concentration in the adsorption in one temperature Adsorption Isotherm will be the representative for explaining about the adsorption equilibrium which will have a lot of benefit for finding the adsorption ability in the dirty water and compare which substance is the best adsorption (19,20).

Adsorption Isotherm have a lot of theory that can explain about the adsorption equilibrium but the popular theory is Langmuir Theory and Freundlich Theory (19)

2.3.4.1 Langmuir Theory (20)

Langmuir adsorption isotherm has a basic hypothesis called ideal localized monolayer model

1. Molecule will be adsorb on the limited surface area
2. Each area of adsorb substance will suitable for the monolayer molecule
3. The surface area of adsorption will limited the number of molecule for adsorption
4. Force of adsorption will similar for every adsorption surface

Beside this Adsorption Molecule can not move or across the surface or react to other molecule from this hypothesis can call Langmuir (Langmuir Equation)

By
$$q = \frac{q_m K_A C}{1 + K_A C} \quad (2.1)$$

$$\frac{C}{q} = \frac{1}{K_A q_m} + \frac{C}{q_m} \quad (2.2)$$

$$\frac{1}{q} = \frac{1}{q_m} + \frac{(1)}{K_A q_m C} \quad (2.3)$$

where ;

Q	=	Substance quantity per adsorption weight
Q_m	=	Substance quantity per adsorption weight for complete monolayer
C	=	Concentrate of solute at equilibrium point
K_a	=	The state of adsorption heat

When drawing graph between c/q and C we will get the picture as 2-2(a) and between $1/q$ and $1/c$ will get the picture 2-2(b) and can find the result of K_a and q_m from the slope and dot on Y. In the graph of 2-2(a) the slop is equal $1/q_m$ and on Y is equal $1/K_a q_m$ and from the picture of 2-2(b) the slope is equal $1/K_a q_m$ and at the Y is equal $1/q_m$.

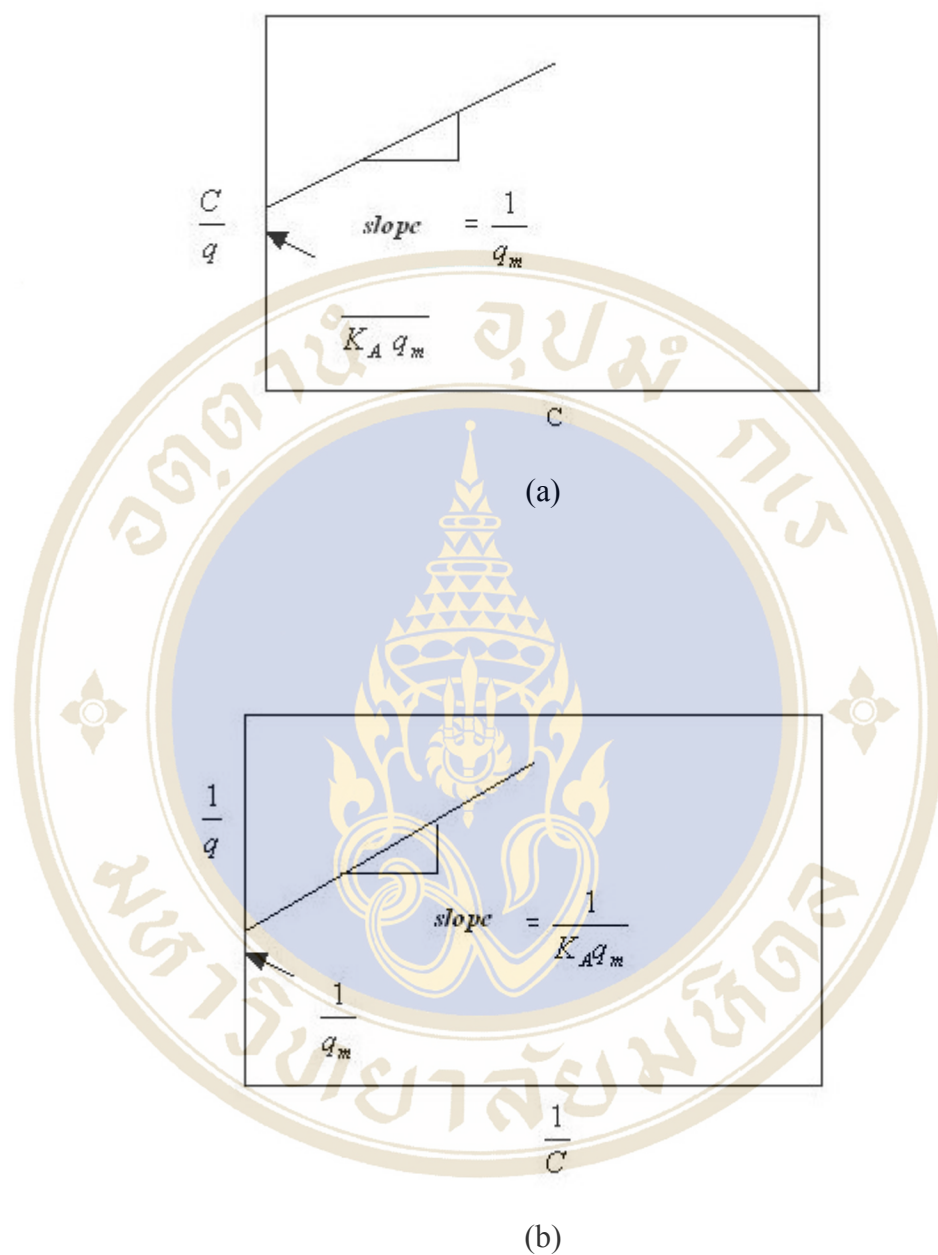


Figure 2-2 Characteristics of Langmuir Adsorption Isotherm in linear form (20)

2.3.4.2 Freundlich Theory

Adsorption Equation of Freundlich, mostly will use in the detail of Mathematic of adsorption in aqueous system (20)

$$\text{By } \frac{X}{M} = K_F C^{1/n} \quad (2.4)$$

$$\text{Or } \log \frac{X}{M} = \log K_F + \frac{1}{n} \log C \quad (2.5)$$

Where ;
 X = Quantity of solute which has been adsorbed
 M = Weight of adsorption
 C = Concentrate of solute at equilibrium point
 K_f and n is stable value which will depend on the temperature of adsorption substance

Used $\log X/M$ and $\log C$ to draw the graph will get figure 3 the slope is $1/n$ and Y equal $\log K_f$

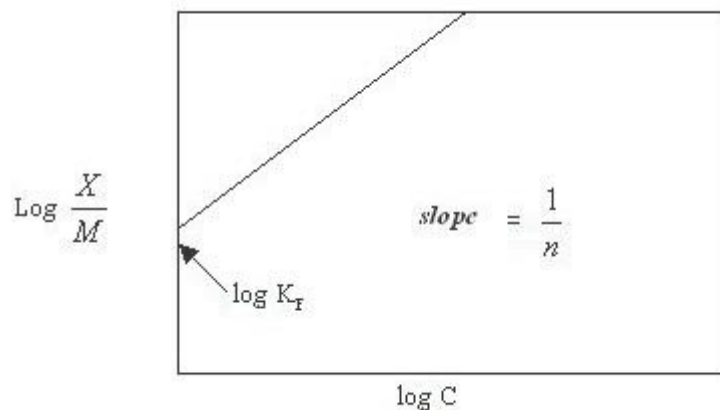


Figure 2-3 Graph of stable value of K_f and n of Freundlich Adsorption Isotherm (20)

2.3.5 The continuing adsorb system (20)

The continuing adsorb system is the system which have many acceptance more than continuing pour system. It use with a lot of dirty water. The continuing adsorb system have 3 types which are Fixed Bed, Moving Bed and Fluidized Bed for this Thesis use Fixed Bed experiment as details below;

This system dirty water will flow to the state of fixed bed no movement (up and down) the adsorption will happen on the top of the system and adsorption area will slowly move down to the bottom of the stage until the end of the fixed bed which will show the result at Picture No.4 at the point when the adsorption not work properly we called the Breakpoint and after this point the graph will have higher curve which mean the ability of adsorption is low and can not use anymore we called Breakthrough Curve, when hit to the C_e Point we called Exhaustion Point and the time count from the start until hit the breakpoint called Breakpoint Time

Breakpoint Time will decrease when

- 1.The increase of filter adsorption
- 2.Bigger size of adsorption substance
- 3.Higher ration of dirty water
- 4.Higher concentrate of adsorption substance

Breakpoint Time will increase when

- 1.The increase of filter adsorption
- 2.Decrease the flow of water
- 3.Decrease the concentrate of water substance in the system
- 4.Reduce the size of adsorption substance to increase surface area

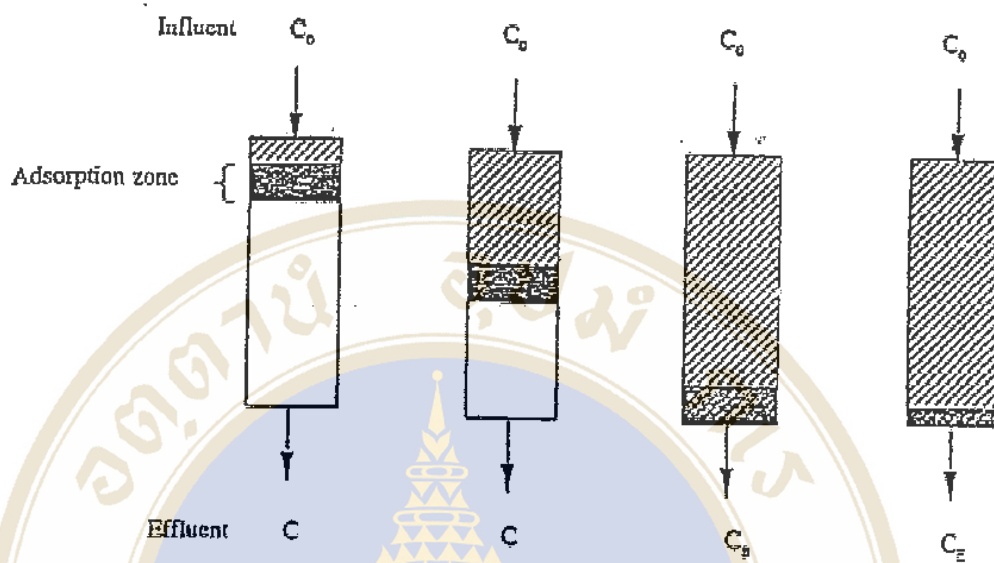


Figure 2-4 The movement of Adsorption Zone for the fix bad filter which will flow from the top down to the bottom. (20)

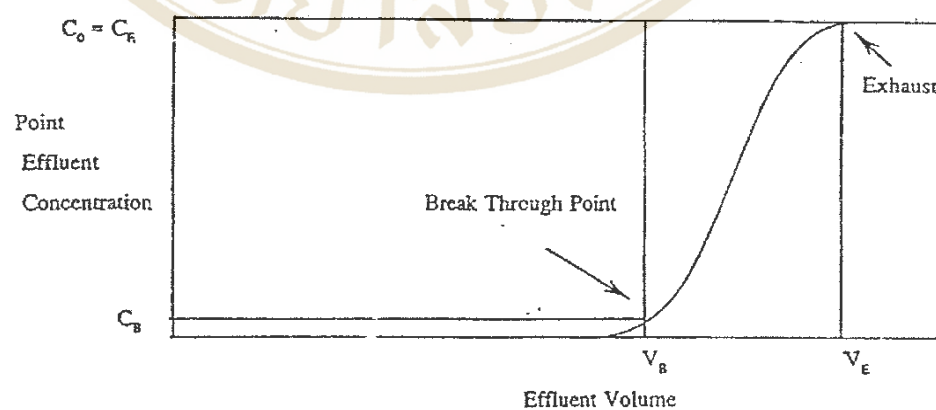


Figure 2-5 The Picture show the Breakthrough Curve for the fix bed (20)

How we can use Type of Water flow: Water flow has 2 types which are

Downflow : Let the water down flow by used the gravity but when hit to the breakpoint, it need to make over again for the whole column

Upflow : Must use the energy in water push it through a substance absorbs to go up above , but the good thing is it can recover when it hit the breakpoint, by eliminate at the bottom the column , when it done recovering state put it back on the top of the column.

Before design the continuing system have to consider as bellows (21);

1. Want the water to flow Downflow or Upflow.
2. Will used as serial or the parallel
3. If want the water downflow will let it flow by itself or pressure
4. If want the water upflow will used what kind of the stage of the filter
5. what kind of tank that will used

The limited by Column Experiment

When get rid of dirty water by column, have to consider this factor as well.

1. Time : Normally will not more than 30 minutes because if used more than that will cause none oxygen stage and will get hydrogen in the column because in column has sulphur as well

2. Type of organic, it is polar or non polar molecule, the number of atom, the molecule of adsorption substance have to smaller than pore.

3. Size of Surface area

2.4 Blood cockle shell

Blood cockle shell or Ark shell is bivalve mollusks of the family Arcidae. Normally organisms in this Mollusca Phylum are composed of calms, squids, cuttlefish, octopus, and chitons for instances. Mollusks are divided to almost 10,000 species and are counted as second numerous organisms down from insects in the Insecta class. Ark shells are bivalves with a soft body and mucus, which these characteristics were named later as the Phylum 'Mollusca'. Due to the fact that most

shells have soft body, therefore it's a necessary to have such a heavy toothed shell.(22)

Blood cockle shell are normally found around the bottom of the shallow beach that is made up by wet sticky soft earth or clay. Most found in Chonburi, Samutsongkram, Samutsakorn, Phetburi, Surat Thani, and Patthani provinces (23).

2.4.1 The blood cockle shell structure

The shell of the blood cockle is made during early embryonic developmental stages (Veliger stage). The Blood cockle shell will increase its shell's thickness and size accordantly with its body growth. The shell which is made in later stage is constructed from Mantel membrane. The shell of bivalves such as cockle is consisted of 3 layers which are the following (22)

1. Periostracum is the colored thin outermost shell which contains 'Conchiolin' protein, which is a kind of protein as hard as the protein found in animal's horn, as its chemical composition.
2. Prismatic is the middle layer shell which is thicker than other two layers. Chemical composition is a highly condensed crystal of calcium carbonate which is perpendicular to the first layer. Besides, crystal of calcite aragonite is also found in this layer.
3. Nacreous is the innermost shell which is the crystal of calcium carbonate in the thin and flat form. These thin and flat films are glossy and they are piled up on one another to make up 'Pearl,' thus, this layer is named 'the Pearl layer.'

2.4.2 Properties of calcium carbonate

In general, calcium carbonate (CaCO_3) is the major component of blood cockle shell. CaCO_3 in blood cockle shell has 3 structures which are the following.

1. Calcite is the rhombohedral crystal with the specific gravity of 2.71. It has moderate hardness which derived from limestone, marble and the shell itself.
2. Aragonite is consisted of crystal in prism or duo-pyramid like which is called orthorhombic. Many orthorhombic normally corporate themselves, in turn resembling a rose. It has the 2.93 specific gravity and is harder than calcite.

When Aragonite is heated, it will change its form to calcite. Aragonite is found in most Mollusks' shells.

3. Vaterite. Vaterite is a circular kind of crystal.

2.4.3 Chemical composition of the blood cockle shell (8)

Blood cockle shell has carbonate substances as its major component, about 60-80 % in weight. From the study of the shell's components in details by using X-ray fluorescence, found that magnesium oxide, silicon dioxide, ferrous oxide and alumina are the minerals that make up the shell's chemical composition.

Besides, by using X-Ray Diffraction technique, α and β keratin are also found in the shell and with chemical analysis, protein and carbohydrate are the found compounds.

2.5 Relevant Research

Relevant research are divided to

2.5.1 Research in shells utilization

Poomngam (24) had studied green mussel and blood cockle shell in lead decreasing, found that blood cockle shell with the size of 20-60 mesh can best discarded lead with the P constant adsorbent of Freundlich equal to 9.46×10^5 mg Pb / shell 1 gram. When continuously studied the wastewater from Batteries' industry which contained Pb concentration of 5.98 mg/liter, found that the column with 1.9 cm diameter, contained blood cockle shell at 2.3 cm high at the 0.5 liter/hr moving rate, can treat 6 liters of Pb contaminated water with the ability to continuously adsorbed Pb equal to 8.6 mg/shell 1 gram.

Patpu (8) studied the use of mountainous stone and blood cockle shell in discarding fluoride in drinking water. She found that when using 12 hr cycle system, at the filtration rate of $0.1 \text{ m}^3 / \text{m}^2 \cdot \text{hr}$, with 60 cm. high surface attached item. Mountainous stone and blood cockle shell had average efficiency in discarding

fluoride more than 85% and when applied them with real sample of underground water, which had fluoride concentration of 8.10mg/liter, found that the mountainous stone and blood cockle shell had an average efficiency in discarding the fluoride at 94.80% and 83.24% in order.

Trongsatikul (25) studied the fluoride disposing in drinking water by using clam shell with overfilling water rate of $0.05 \text{ m}^3 / \text{m}^2 \cdot \text{hr}$. She found that clam shell had fluoride disposing efficiency of 78.48% with the 4 hr working life span.

Kwon (5) had studied the phosphorus disposing in wastewater by oyster's shell. Kwon found that oyster's shell that pre-heated at 750°C under nitrogen filling atmosphere can dispose phosphorus to 98%. In addition, oyster shell that pre-heated at 750°C in normal atmosphere can discard phosphorus up to 68%

2.5.2 Research involved in Nitrogen and phosphorus disposing

Thongtong (26) studied the disposing of nitrogen (N) and phosphorus (P) in wastewater from community by using algae (*Uronema* sp.81) with the all in one method, Thongtong found that algae can optimally discards nitrogen to 72.17% in 10 days and able to discard phosphorus up to 32.24 % in 12 days. In opposite, the continuous way of culturing the cell, by using water moving rate at 2, 4, and 8 liters/day, showed lower efficiency in N & P disposing rate. Wastewater that entered the system with low moving rate will be better treated.

Taweessup (27) studied the effectiveness in phosphorus disposing by using sand filter and anthracite. Each model was composed of 60 and 90 cm thick 2 layers filter, using filtering rate of $2 \text{ gallons} / \text{ft}^2 \cdot \text{min}$ for 10 hr. Aujjara found that effectiveness in phosphorus disposing with the 30:30 and 30:60 ratio (cm-thick) between sand filter and anthracite was similarly rated.

Khonkhaysap (28) studied nitrogen and phosphorus disposing in wastewater that had been treated by aeration tank and sedimentation inducing by using chemicals. Three sediment inducing agents were aluminium sulfate (alum), ferric chloride and calcium oxide. The founding was that the alum was the best agent in causing precipitation in wastewater treatment. The proficiency was that it can clear out 99.67% dirty substance in suspensions and turned obscure water into crystal clear. Alum can also discard nitrogen (TKN) and phosphorus to 24.07% and 96.29% in order.

Thawornjarernpong (29) studied phosphorus (P) disposing by using concrete waste, found that at the overfilling rate, the phosphorus concentration was lower, and the smaller size concrete had more effectiveness in P disposing. The concrete waste working life span was longer at the overfilling water rate, the started P concentration was higher and the concrete size was bigger.

Wuttiyingyong (7) studied phosphorus disposing in synthetic wastewater by using hard pan in both Batch and Column experiments. The column in the experiment, contained 30 cm and 45 cm high hard pan, and had moving wastewater rate of $0.6 \text{ m}^3 / \text{m}^2 \cdot \text{hr}$. When conducting experiment continuously for 8 hr, and collecting water sample every 1 hr, the height of hard pan layers affected the phosphorus disposing efficiency by the greater height associated with greater disposing capability. This founding had significant statistical reliability.

Sripunya (30) studied nitrogen disposing in shrimp larvae nurturing tank by nitrification process, found that adding nitrifying bacteria in the cells holder can accelerate the nitrification process to minimize the accumulation of ammonia and nitrite in the tank. In addition, when using the closed circulation, not only it had enhanced the treatment's efficiency but the survival rate of the shrimp larvae also increased.

2.5.3 Research associated with water treatment in shrimp farm

Kaewsuralikhit (31) studied the use of *Gracilaria fisheri* algae in order to minimize ammonium nitrite, nitrate and phosphate in effluent from the shrimp farm. The conducted experiment was held in cement tank with 1.75 m diameter at the depth of 30 cm. The algae were raised in 3 different densities which are 0.25, 0.55 and 1.0 kg/ m². The result was that the concentrations of ammonium nitrite, nitrate and phosphate were maximally decreased when treating with 1.0 kg/ m² dense algae.

Thirakphun (32) studied the use of green mussel to better the effluent quality from shrimp farm. This experiment studied the changing water properties in prawn-raising tank with 3.46 × 1,600 m² tank size, prawn launching rate of 34/m², 1 month aged prawn, and the densities of mussel (specified to 4 levels which are 1, 3, 5, and 7 kg/ 1 ton of effluent). The study showed that 1 kg dense of mussel was the suitable ratio for treating 1 ton of waster from prawn raising farm.

Tunsutapanich et al. (33) studied way to restore the farming of Tiger prawn and its recycle system environment. The team used aquatic plants which were many species of algae; *Gracilaria fisheri*, *Cualerpa sp.*, *Ruppia sp.* and many species of fish which e were the sea bass, mullet fish, white milky fish and other aquatic animals to experiment the clay and effluent cycling treatment, in an attempt to restore clay and effluent from generation 2 to be reused in generation 3. The results showed that such aquatics plants and animals can better the clay and effluent conditions using in second generation and the treated water can also be reused fairly in the third generation.

Tunvilai (34) studied the control of effluent quality from Tiger prawn developed farm by the 'Artemia.' Artemia were raised with the density of 100 artemias: 1 liter in 315 liters of effluent from tiger prawn farm, in 50 cm high circular tank with 100 m in diameter. The experiment was held for 14 days. The result revealed that nitrite-nitrogen rate increased from 0.020 mg/liter to 0.412 mg/liter, nitrite-nitrogen rate increased from 1.8 mg/liter to 5.0 mg/liter, and orthophosphate rate increased from 0.047 mg/liter to 0.159 mg/liter.

Chaiyakam and Tunvilai (35) had experimentally used green mussel with *Gracilaria fisheri* algae to bio-treated the effluent from tiger prawn developed farm by experimenting in 200 liters tank, 2 types. The first type used 168 ± 2 g of algae and 200 ± 2 g of mussel. The second type used algae weighted 340 ± 2 g and mussel weighted 400 ± 1.5 gram. The experiments were divided into 4 groups and were repeated 3 times, consisted of the control set, the algae set, the mussel set and the set that combined both algae and mussel. The water quality was studied at the 0, 6, 12, 18, 24, 48 hr. From the results, the algae and mussel sets could decrease organic substances, plankton and suspensions, while the changing rates of BOD, COD, ammonia-nitrite, nitrate-nitrogen, suspensions and chlorophyll-A in the control set were not show much differences from the combined set because the elimination by mussel increased ammonium level all along the experimental period so the aeration technique should be added to better effluent quality.

Khidprasert (36) studied the discarding of nitrogen in effluent from shrimp farm using seaweed family Caulerpa, Sargassum, and Gracilaria. The effluent tank from the farm had densities of 1, 5, and 10 gram / liters. Water quality was first observed before conducting the experiment then later checked after had been treated with seaweed for 6, 12, 18, 24, and 72 hr. Ammonia and nitrogen were rated. The result was that seaweed in all species can best decrease the concentration of ammonia-nitrogen and nitrate-nitrogen. In addition, the ability to decrease the concentration of organic substances was tied tightly with the type of those organic substances themselves. And for the seaweed Gracilaria, the finding was that in almost every experimental stages, the seaweed with the density as high as 10 g/liter can lower amount of ammonia better than the low density seaweed. But low dense seaweed at 1 g / liter had higher ammonia adsorption rate. For nitrate, seaweed with the density of 5 g / liter can lower the amount of nitrate better than the seaweed with 10 and 1 g. / liter dense. Seaweed with densities of 5 and 10 g / liter also possessed nearly alike adsorption rate and that rate was better than the rate of the 1 g / liter seaweed.

Sawatphong (37) had tried raising sea grasses (*Halophila Ovalis*) to decrease BOD rate, amounts of nitrogen and phosphorus in effluent coming from the shrimp farming. The experiment used 1.0 kg/m², 2.00 kg/m² and 3.00 kg/m² sea-grasses in fiber tank that contained 250 liters of effluent. The control set which was purely contained effluent was also included in the experiment. Finding was that raising the sea grasses could make BOD equal to 64.64 % - 80.63%, 77.85% - 92.05%, 69.83%-74.01%, 76.59%-85.22% and 65.33%-75.11% sequentially.

Tunsutapanich (38) had suggested the bio-treatment by specifically and separately bio-treating each tank, tank by tank with the suggestion that each tank should corporately habituate many kinds of aquatic animals and plants together, except for the tank that contained herbivores should be installed the aeration machine to prevent stratification in the water. Natural mechanism happened in each tank can eventually restore the water to its balance then the water could again be suitable for prawn farming or the balance in water could be reached by bringing problematic natural aqua to be bio-treated by applying chemicals in the concentration that can only neutral the pH in the water. The water that was treated this way can be further used for shrimp farming.

PhawaPhutanont Na Mahasarakam (39) had tried to long stand farmed the tiger shrimp with bio-water treatment. He raised shrimp in the experimental tank and directed effluent from the tank to 3 different revived tanks with the first tank having green mussel, second tank having the *Gracilaria fisheri* algae, and the third one having none living organisms in it. The results showed green mussel and *Gracilaria fisheri* algae had the potential in reducing chemicals, especially algae played essential role in reducing nitrogen compounds even mussel were responsible for adding ammonia and nitrogen to the water all along the experimental duration. Water quality in the farming tank had increasing ammonia-nitrogen, nitrite-nitrogen, nitrate – nitrogen and BOD rates, while water in revived tank had decreasing ammonia-nitrogen, nitrite-nitrogen, nitrate – nitrogen and BOD rates.

CHAPTER III

MATERIAL AND METHODS

3.1 Research Structures

The experimental study in this research uses vitro column filtration system. The cylinder glass tube used to contain both blood cockle shell and effluent. This study was a continuous study to evaluate the efficiency in total nitrogen and phosphorus disposing in effluent from shrimp farm. Including the use of different sizes of ask shells to compare their total nitrogen and phosphorus reducing capabilities. In addition, the efficiencies in reducing total nitrogen and phosphorus at different rates of the flow water was measured.

3.2 Tools chemicals and experimental equipments

3.2.1 Experimental tools

- Sieve no. 10, 20, 45, and 50 mesh
- pH meter
- Oven
- Grinder
- TKN glass set
- Weighing balance
- Hot plate
- Glassware in Laboratory

3.2.2 Experimental equipments

- Glass column, 3 inches in diameter
- Cylinder plastic container, volume 4.5 gallon, for containing to be entering into the system effluent.

3.2.3 Analytical tools

- Analysis of Shell's surface by Scanning Electron Microscope (SEM)
- Analysis of phosphorus concentration with UV Spectrophotometer at the wavelength 880 millimicron.
- Analysis of total nitrogen by TKN set

3.2.4 Chemical Solutions

- Phenolphthalene Indicator
- Sulfuric acid solution (H_2SO_4)
- Ammonium Molybdate $[(\text{NH}_4)_6\text{Mo}_7\text{O}_{24} \cdot 4\text{H}_2\text{O}]$
- Antimony Potassium Tartrate $[\text{K}(\text{SbO})\text{-C}_4\text{H}_4\text{O}_6 \cdot 1/2\text{H}_2\text{O}]$
- Ascorbic acid
- Potassium per sulfate $[\text{K}_2\text{S}_2\text{O}_8]$
- Sodium hydroxide (NaOH)
- Mercuric sulfate (HgO_4)
- Potassium sulfate (K_2SO_4)
- Sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$)
- Boric acid (H_3BO_3)
- Methyl red
- Methylene blue
- 95% alcohol

3.3 Experimental Steps

This experiment is divided into 5 steps which are the following

1. Blood cockle shell preparation
2. Quality analysis of effluent from tiger shrimp farming.
3. Physical characteristics analysis of burned blood cockle shell
4. Evaluating of the total nitrogen and phosphorus disposing efficiencies of blood cockle shell at different sizes, also at different water entering column rates, and the comparisons in the effectiveness of the burned blood cockle shell, natural shell, and activated charcoal's phosphorus and nitrogen disposing abilities.

5. Studying of isotherm adsorption

3.3.1 Blood cockle shell preparation

Immersing the collected shell into clean water for 12 hr, then brushing them until all the fresh parts will be removed. Rinse well, leave to dry then put into oven at temperature equals 750° C for 1 hr (35) then divided into 3 parts. The first part is grounded to 0.85-2.0 millimeter, the second part is grounded into the size of 0.3 – 0.35 millimeter and the last part is larger than 2.0 millimeter.

3.3.2 Analysis of effluent quality from shrimp farm using standard methods for the examination of water and wastewater 1992. The analysis can be concluded as the following

1. pH (measured by numeric pH and temperature indicator)
2. Alkalinity (using indicator method)
3. Total phosphorus, using Persulfate digestion / Ascorbic acid method
4. Total nitrogen rate, using total Kjeldahl Nitrogen (TKN)
5. BOD using Azide modification: 20°C : 5 days

3.3.3 Analysis of Blood cockle shell's physical properties

Studying the specific surface area and Blood cockle shell's density with Bunauer machine, Emmett and Teller method (BET), also study the shell's structure, including the pore size by using Scanning electron Microscopy (SEM)

3.3.4 Testing the total nitrogen and phosphorus disposing efficiency at different blood cockle shell's size and at the different column entering rates.

3.3.4.1 Experiment of the total nitrogen and phosphorus removal efficiency at different blood cockle shell's size

1. Place 0.85-2.0 millimeter burned blood cockle shell in glass column at 60 cm. high.
2. Release effluent into the column with a constant rate.
3. Collect water sample after exited the column every 1 hr for 8 hr, then analyzing the remaining phosphorus and total nitrogen.

4. Repeat the experiment from step 1 – step 3 but changing the burn blood cockle shell size from 0.85 – 2.0 mm to 0.3 – 0.35 mm and to larger than 2.0mm burn blood cockle shell in order.

5. Repeat the experiment from step 1 – step 4, 2 times

3.3.4.2 Experiment the efficiency of the total nitrogen and phosphorus removing at different water to column entering rates.

1. Place the burned blood cockle shell size with the highest adsorption ability in 3.3.4.1 in glass column at the 60 cm. high.

2. Release effluent into the column with a constant flow rate in 3.3.4.1

3. Collect water sample after exiting the column every 1 hour for 8 hours, then analyzing the remaining amount of total nitrogen and phosphorus in the water.

4. Repeat the experiment from step 1 – 3 but change the constant flow rate from the one in 3.3.4.1 to the rate of 1x, 2x and 3x faster.

5. Repeat the experiment from step 1 – 4, 2 times.

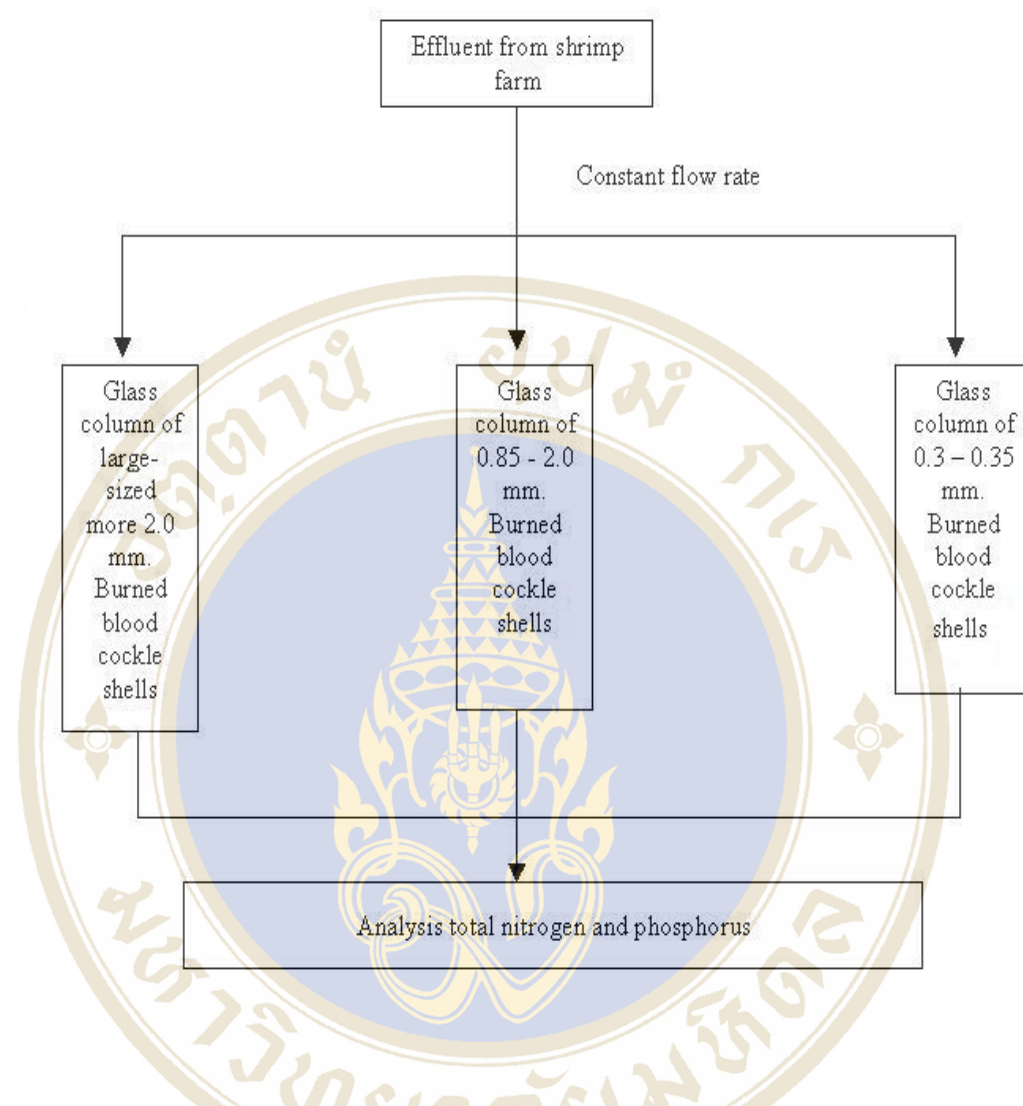


Figure 3-1 Diagram of experimenting the total nitrogen and phosphorus removal efficiency at different burn blood cockle shell's size

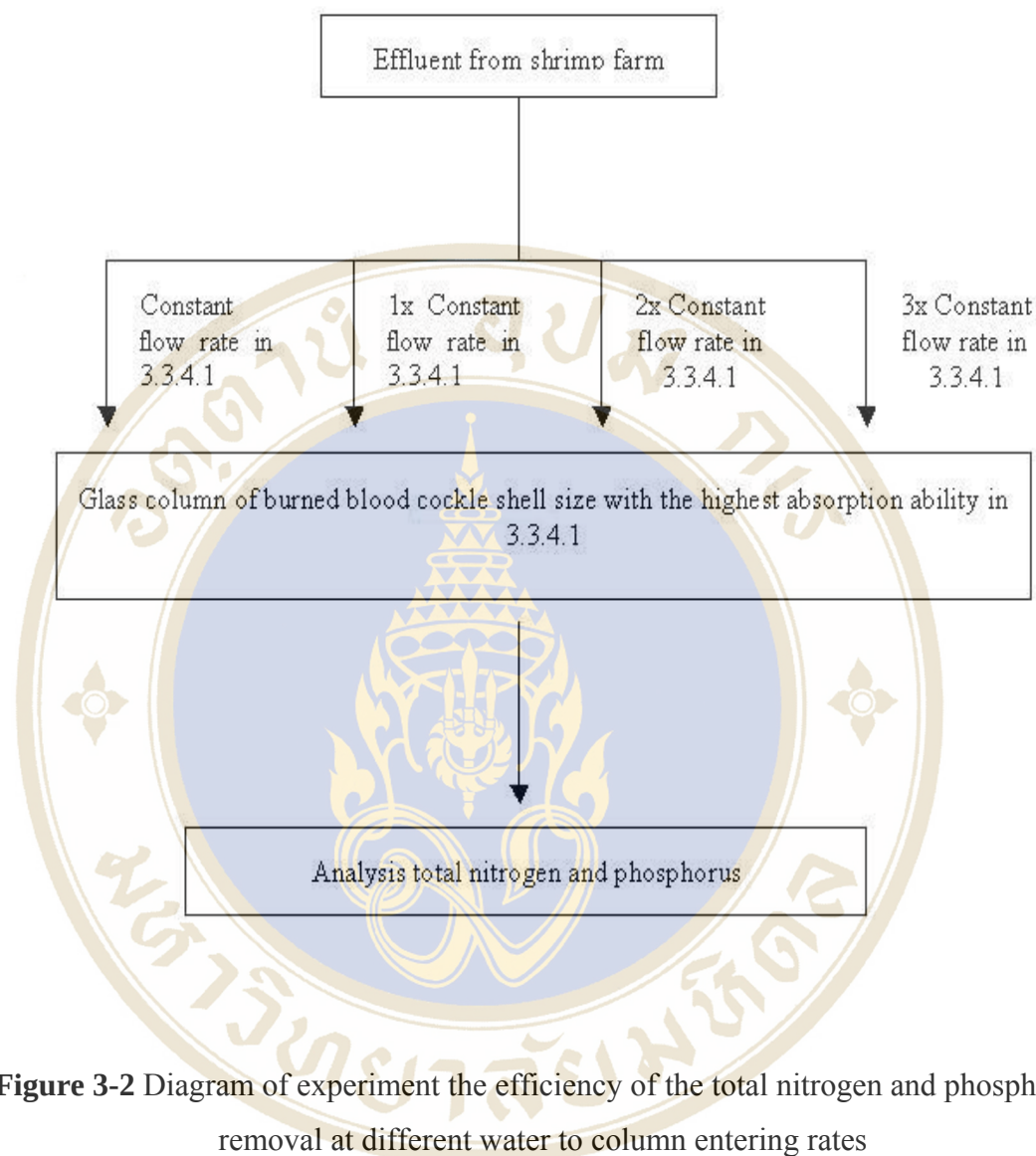


Figure 3-2 Diagram of experiment the efficiency of the total nitrogen and phosphorus removal at different water to column entering rates

3.3.4.3 Studying the total nitrogen and phosphorus reducing rates to be compared between burned blood cockle shell, natural blood cockle shell and Activated Charcoal at the best water flow rate.

1. Place the blood cockle shell size with the highest adsorption ability in 3.3.4.1 in glass column at the 60 cm. high.

2. Release the effluent into the column with the best flow rate in 3.3.4.2

3. Collect water sample after exiting the column every 1 hour for 8 hours, then analyzing the remaining amount of nitrogen and phosphorus in the water.

4. Repeat the experiment from step 1 – 3, but changing from burned blood cockle shell to the natural shell (with the size as similar as the burned shell, which possesses the best adsorption ability in 3.3.4.1.), and also changing to the Activated charcoal at last.

5. Repeat the experiment from step 1 – 4, 2 times.

3.3.5 Absorption Isotherm Studying

1. Place the blood cockle shell size with highest adsorption ability in 3.3.4.1 in glass column at 60 cm. high

2. Release effluent that contains nitrogen and phosphorus solutions at concentration 1 mg nitrogen / liter and 1 mg phosphorus / liter into the column with the best constant flow rate in 3.3.4.2

3. Collect water sample, after exiting the column, every 1 hour for 8 hours, then analyzing the remaining amount of over all nitrogen and phosphorus in the water. Then construct the logarithm graphs between total concentration of nitrogen and remaining phosphorus in the water, between also the amount of nitrogen and phosphorus that are adsorbed per an adsorbent weight. (Adsorbate : Adsorbent)

4. Repeat the experiment from step 1 to 3 but change the concentration of the nitrogen and phosphorus solutions to the concentration at

1) 5 mg. nitrogen / liter, 5 mg phosphorus / liter

2) 10 mg. nitrogen / liter, 10 mg phosphorus / liter

3) 15 mg. nitrogen / liter, 15 mg phosphorus / liter

5. Repeat the experiment from step 1 – 4, 2 times for each concentration

3.4 Statistical Analysis

Descriptive Statistics

Use average ($\bar{x}$) Standard distribution (S.D.) to explain general properties of the Total nitrogen and phosphorus disposing efficiency in each experiment.

Demonstrate information on the ability in Total nitrogen and phosphorus disposing by Line and percent graphs.

Inferential Statistics

Testing of the differences in the efficiency of each conducted experiment for all nitrogen and phosphorus disposing task. Use ANOVA to analyze the variability with the reliability $\alpha = 0.05$

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Analysis of effluent quality from shrimp farming

The effluent from feeding Black Tiger shrimps case study brought from Mr.Dacha Saeheng farm. Water example was collected applies in experiment monthly. The effluent quality as follows: pH 8.3 – 8.5 Hardness 11.7 – 12.1 milligrams/liter Phosphorus 0.85 – 2.21 milligrams phosphorus/liter Total nitrogen 7.84 – 12.6nitrogen milligrams/liter and BOD at 4.68 – 5.65 milligrams/liter (table 4-1)

Table 4-1 Effluent quality analysis from Black Tiger shrimps culture

Parameter	Unit	Value of each parameter
pH	-	8.3 - 8.5
Hardness	mg/L	11.7 – 12.1
Total Phosphorus	mg-P /L	0.85 – 2.21
Total Nitrogen	mg-N/L	7.84 – 12.6
BOD	mg/L	4.68 – 5.65

4.2 Analysis of Blood cockle shell's physical properties

From characteristics of burned blood cockle shell and that still no burned such as; BET surface area and average pore size that analyze with Gas Sorption Analyzer by Bunauer, Emmett and Teller method (BET). Found that the burned blood cockle shell had BET surface area 1.85 square meters/gram average pore volume 0.002 cubic centimeter/gram and average pore size 38.39 angstrom. And blood cockle shell that still no burned had BET surface area 1.72 square meters/gram average pore volume 0.002 cubic centimeter/gram and average pore size 37.24 angstrom (tables 4-2)

Table 4-2 Physical Character analysis of burned blood cockle shell and natural blood cockle shell

Sample	BET Surface	Average Pore	Average Pore
	Area (m ² /g)	Volume (cm ³ /g)	Size (A°)
burned blood cockle shell	1.85	0.002	38.39
natural blood cockle shell	1.72	0.002	37.24

Case studies structure that pore size of blood cockle shell by Scanning Electron Microscopy (SEM). In the photography for saw the size of pore size must be force against enlarged that 5,000-10,000 then would be obviously (figure 4-1 to 4-4)

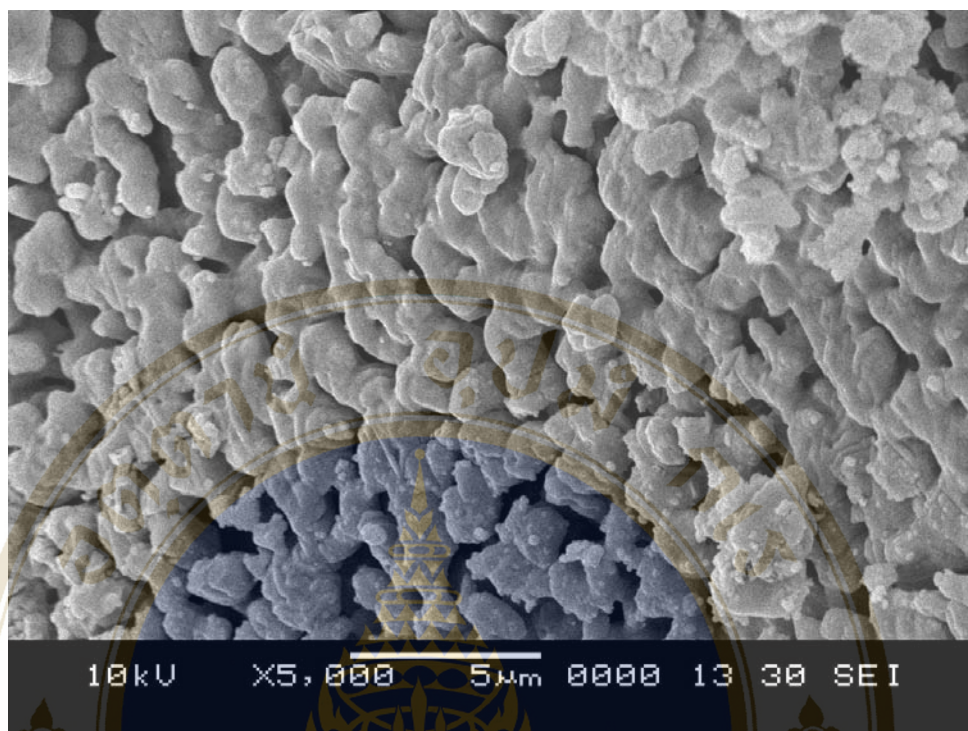


Figure 4-1 Morphology of large-sized more 2.0 mm. burned blood cockle shell with magnification of x 5,000

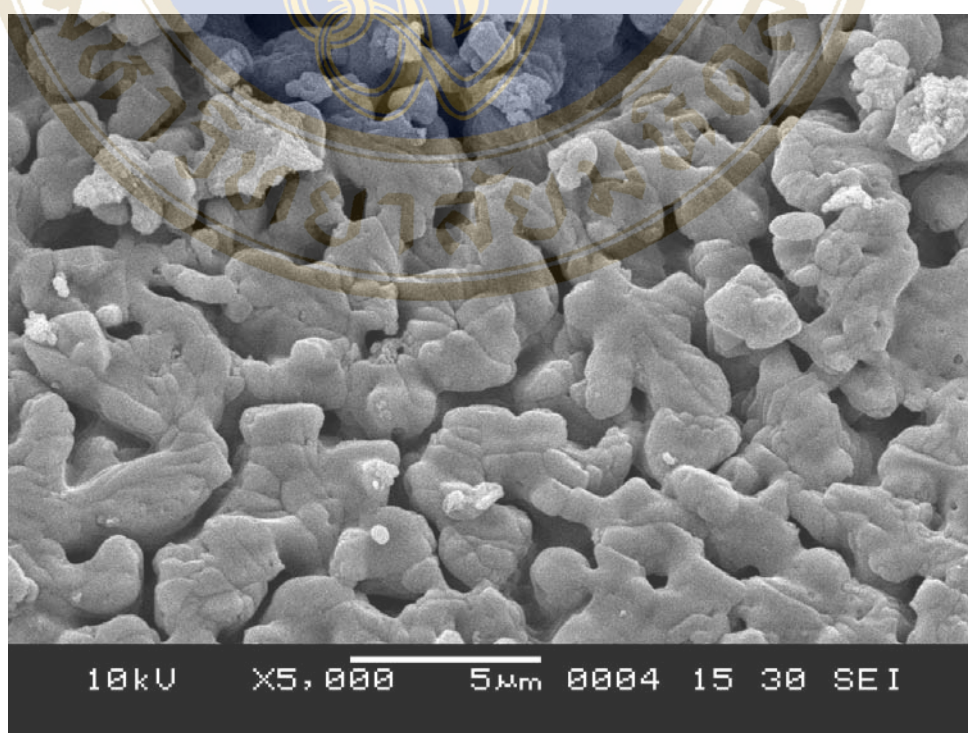


Figure 4-2 Morphology of 0.85 - 2.0 mm. burned blood cockle shell with magnification of x 5,000

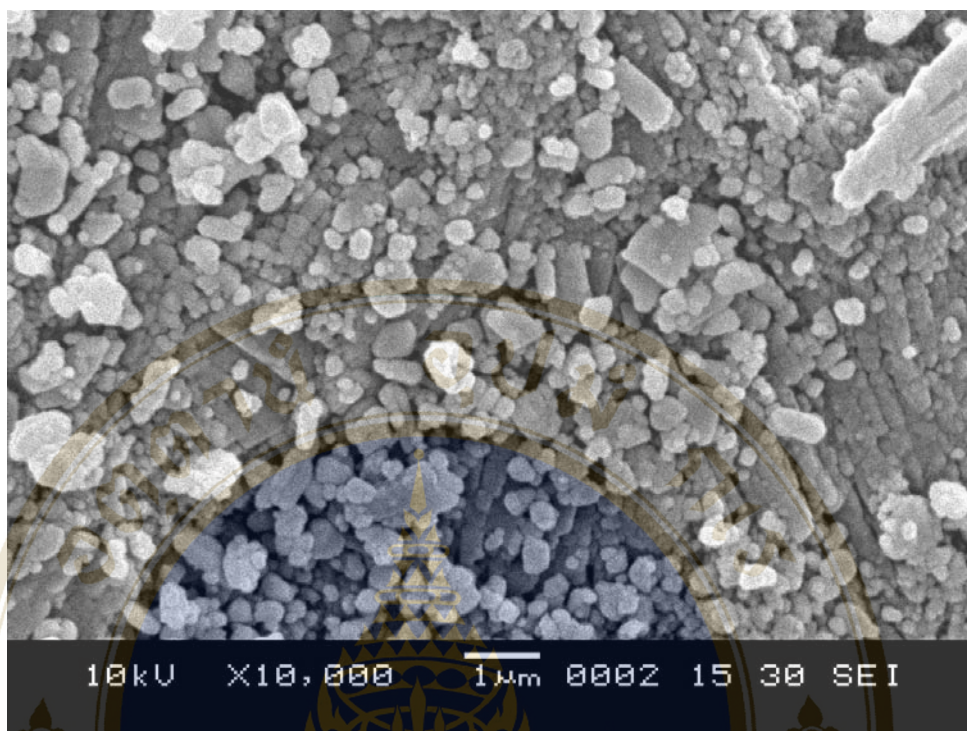


Figure 4-3 Morphology of natural blood cockle shell with magnification of x 10,000

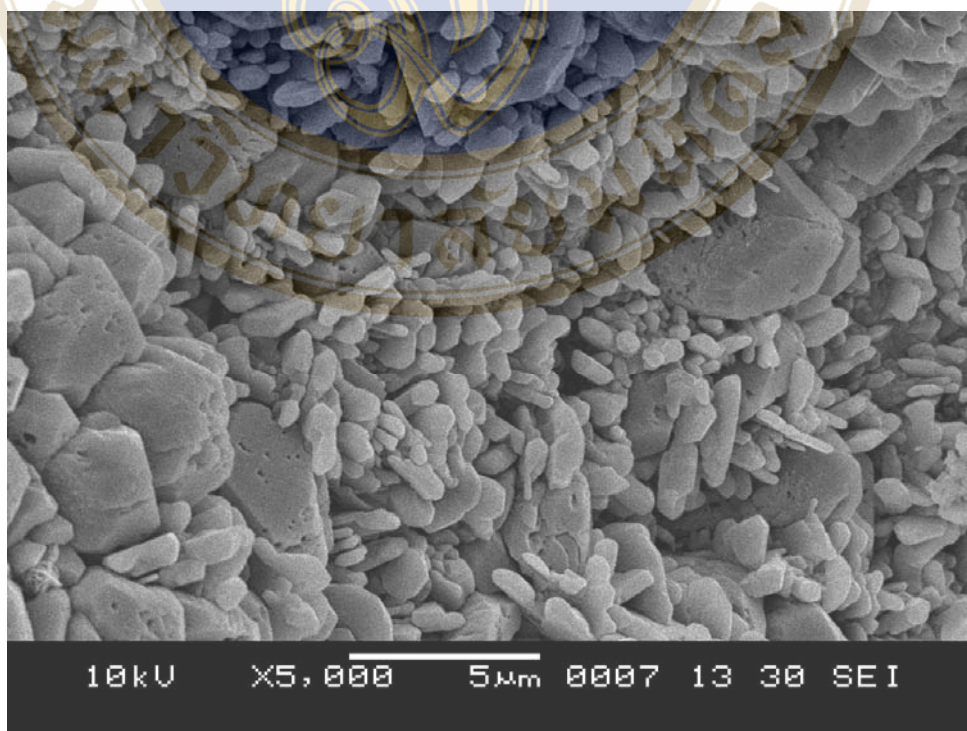


Figure 4-4 Morphology of used 0.85 - 2.0 mm. burned blood cockle shell with magnification of x 5,000

When compared with physical character of burned blood cockle shell and natural blood cockle shell could see that the natural blood cockle shell had BET surface area and pore size had little more than burned blood cockle shell. But average pore size volume was equal which that when used equal capacity would have natural blood cockle shell more than burned blood cockle shell. When observed from figures 4-2 and 4-4 could see that burned blood cockle shell had different character, so burned blood cockle shell already had been used that would have crystal cling in surface and closed pore of burned blood cockle shell which made to know that the absorbing process happen between the total nitrogen and the phosphorus with burned blood cockle shell.

4.3 Testing the total nitrogen and phosphorus removal efficiency at different blood cockle shell's size and at the different column entering rates.

4.3.1 Experiment of the total nitrogen and phosphorus removal efficiency at different blood cockle shell's size

In this test uses 3 blood cockle shell were constant sizes 0.85 - 2.0 millimeter, 0.3 - 0.35 millimeter and large-sized more 2.0 millimeter by flow rate that used in this experiment at 300 milliliter/ hour, so 0.3 - 0.35 millimeter had very small size until became powdery. When packed in the column was blockading, the effluent could not move and must be cancel this experiment. Moreover 2 rest size be 0.85 - 2.0 millimeter, and large-sized more 2.0 millimeter. Found that size at 0.85 - 2.0 millimeter. The best efficient total nitrogen reduction was 86.66 percentages. In hour 4 can decreased phosphorus quantity about 87.63 percentages. Worst efficient total nitrogen quantity reduction was 62.22 percentages at hour 1 and decreased phosphorus quantity 1.81 percentages.

Table 4-3 Efficiency of removal total nitrogen and phosphorus by 0.85 – 2.0 mm. burned blood cockle shell

Time (Hour)	Total Nitrogen		Phosphorus	
	Concentration	Efficiency	Concentration	Efficiency
	(mg-N/L)	(%)	(mg-P/L)	(%)
0	12.6	-	2.21	-
1	4.76	62.22	2.17	1.81
2	3.92	68.88	1.81	14.03
3	2.52	80.0	1.76	48.42
4	1.68	86.66	0.27	87.63
5	3.36	73.33	0.55	74.96
6	3.64	71.11	0.68	69.23
7	4.2	66.66	0.88	60.18
8	4.29	65.92	1.17	47.21

And large-sized more 2.0 millimeter that the best effective for total nitrogen reduction at 70.23 percentages in hour 4. It had best effective in phosphorus reduction at 77.53 percentages at hour 4. However, worst efficiency in the total nitrogen reduction was 28.57 percentages in hour 1 and worst efficiency phosphorus reduction was 53.55 percentages in hour 8. The table was as followed:

Table 4-4 Efficiency of removal total nitrogen and phosphorus by large-sized more 2.0 mm. burned blood cockle shell

Time (Hour)	Total Nitrogen		Phosphorus	
	Concentration	Efficiency	Concentration	Efficiency
	(mg-N/L)	(%)	(mg-P/L)	(%)
0	7.84	-	2.21	-
1	5.6	28.57	0.97	56.26
2	5.13	34.52	0.84	61.99
3	3.64	53.57	0.54	75.41
4	2.33	70.23	0.5	77.53
5	2.52	67.86	0.64	70.89
6	2.8	63.09	0.8	63.8
7	3.73	52.38	0.84	61.99
8	5.13	34.53	1.03	53.55

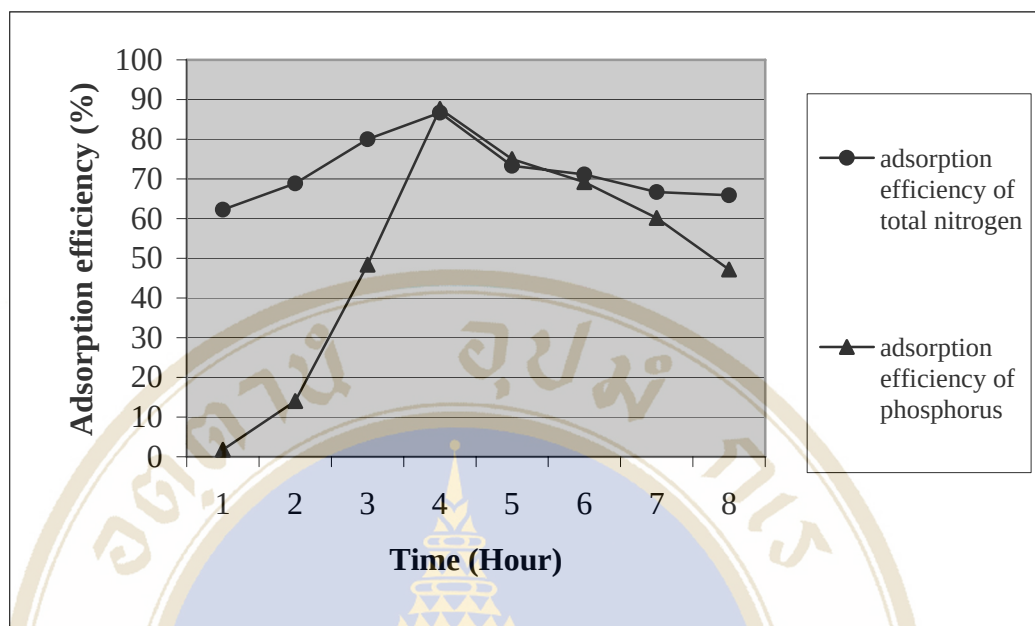


Figure 4-5 Efficiency of total nitrogen and phosphorus removing by 0.85 – 2.0 mm. burned blood cockle shell

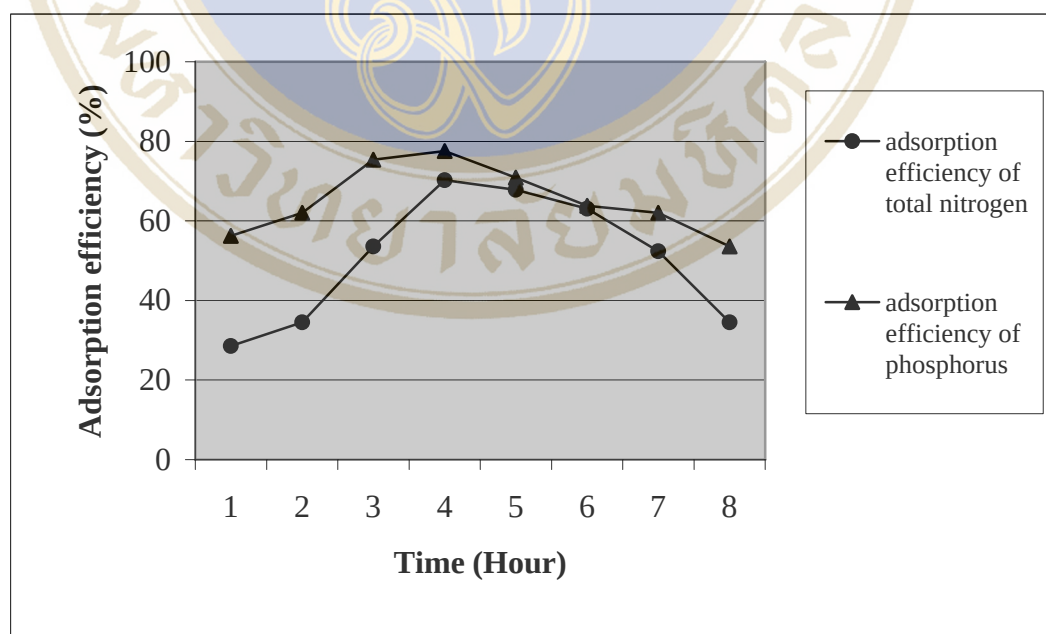


Figure 4-6 Efficiency of total nitrogen and phosphorus removing by large-sized more 2.0 mm. burned blood cockle shell

From figure 4-5 and 4-6, the result could see that the burned blood cockle shell 0.85 -2.0 millimeters had total nitrogen reduction increased effective continuously in the first 4 hour. After that the efficiency would reduce continuously until the experimental ending. It could observe from the slop that shows in figure 4-5. The efficiency of phosphorus quantity reduction would increase quickly during the first 4 hour also; thereafter the efficiency in phosphorus reduction was down continuously also. The blood cockle shells were large-sized more 2.0 millimeter that the efficiency in total nitrogen reduction would be up continuously in the first 4 hour and then the efficiency would gradually reduce until end and from the experiment could observe that the efficiency phosphorus reduction was better than efficiency in total nitrogen reduction a little.

From the experiment it could suggest that the efficiency in total nitrogen and phosphorus reduction of burned blood cockle shells at 0.85 – 2.0 millimeter had effective in total nitrogen quantity reduction and phosphorus quantity reduction be better than blood cockle shell large-sized more 2.0 millimeter. As the different size burned blood cockle shells have BET surface area differently. The burned blood cockle shells 0.85 – 2.0 millimeter that would have BET surface area more than burned blood cockle shell large-size more 2.0 millimeters. Thus the size of burned blood cockle shells that should test next step was 0.85 – 2.0 millimeter because the effective in total nitrogen quantity reduction and phosphorus quantity reduction was better.

4.3.2 Experiment the efficiency of the total nitrogen and phosphorus removing at different water to column entering rates.

From tests 4.3.1, found that the flow rate reached to column at 300 a milliliters/ hour. This flow rate that used different test 3 level at flow rate much as 1 size to be 600 milliliters/hour, at flow rates much as 2 size was 900 milliliters/hour, and at flow rates much as 3 size was 1,200 milliliters/hour. By in this step test would used burned blood cockle shells that had effective in best phosphorus and total nitrogen reduction from 4.3.1 was at 0.85 –2.0 millimeter.

At flow rate 300 milliliters/hour. The burned blood cockle shells had the best effective in total nitrogen reduction at 86.66 percentages in hour 4 and the least

effective in total nitrogen reduction quality was 62.22 percentages in hour 1. And the best efficiency in phosphorus reduction was 87.63 percentages in hour 4 and least effective in phosphorus quantity reduction was 1.81 percentages in hour 1 at flow rate 600 milliliters/hour. The burned blood cockle shells had the best effective in totals nitrogen reduction quantity was 66.66 percentages in hour 4 and had the least effective in total nitrogen quantity reduction at 46.66 percentages in hour 1 and hour 8. Moreover, the best efficiency in phosphorus reduction was at 80 percentages in hour 4 and had the least effective in phosphorus quantity reduction at 1.83 percentages in hour 1 at flow rate 900 milliliters/hour. The burned blood cockle shells had the best effective in total nitrogen quantity reduction at 51.73 percentages in hour 4 and the least effective in total nitrogen quantity reduction at 29.87 percentages in hour 1. Moreover, the best efficiency in phosphorus reduction was at 79.09 percentages in hour 4 and the least effective in phosphorus quantity reduction was at 8.49 percentages in hour 1.

And flow rate was at 1,200 milliliters/hour. The burned blood cockle shells had the best effective in total nitrogen quantity reduction at 46.43 percentages in hour 4 and least effective in total nitrogen quantity reduction was at 21.43 percentages in hour 8. The best efficiency in phosphorus reduction was at 77.65 percentages in hour 3 and the least effective in phosphorus quantity reduction was at 21.96 percentages in hour 1; show on table 4-5 and 4-6.

Table 4-5 Efficiency of total nitrogen removing by 0.85 – 2.0 mm. burned blood cockle shell at different flow rate

Time (Hour)	At flow rate 300 ml./Hour		At flow rate 600 ml./Hour		At flow rate 900 ml./Hour		At flow rate 1,200 ml./Hour	
	Concentration (mgN/L)	Efficiency (%)	Concentration (mgN/L)	Efficiency (%)	Concentration (mgN/L)	Efficiency (%)	Concentration (mgN/L)	Efficiency (%)
0	12.6	-	12.6	-	8.12	-	7.84	-
1	4.76	62.22	6.72	46.66	5.69	29.87	5.23	33.33
2	3.92	68.88	5.69	54.81	5.13	36.78	4.57	39.29
3	2.52	80	5.13	59.26	4.48	44.83	4.48	42.86
4	1.68	86.66	4.2	66.66	3.92	51.73	4.23	46.43
5	3.36	73.33	3.92	68.89	4.01	50.57	4.67	40.47
6	3.64	71.11	4.39	65.18	4.67	42.53	5.23	33.33
7	4.2	66.66	4.76	62.22	5.23	35.63	5.6	28.57
8	4.29	65.92	6.72	46.66	5.69	29.89	6.16	21.43

Table 4-6 Efficiency of phosphorus removing by 0.85 – 2.0 mm. burned blood cockle shell at different flow rate

Time (Hour)	At flow rate 300 ml./Hour		At flow rate 600 ml./Hour		At flow rate 900 ml./Hour		At flow rate 1,200 ml./Hour	
	Concentration (mgN/L)	Efficiency (%)	Concentration (mgN/L)	Efficiency (%)	Concentration (mgN/L)	Efficiency (%)	Concentration (mgN/L)	Efficiency (%)
0	2.21	-	2	-	2.2	-	0.85	-
1	2.17	1.81	1.96	1.83	2.01	8.49	0.66	21.96
2	1.81	14.03	0.47	78	1.1	49.85	0.32	62.35
3	1.76	48.42	0.42	79	0.53	75.76	0.19	77.65
4	0.27	87.63	0.4	80	0.46	79.09	0.33	61.57
5	0.55	74.96	0.47	76.67	0.48	78.18	0.37	56.08
6	0.68	69.23	0.51	74.5	0.53	75.9	0.44	48.24
7	0.88	60.18	0.53	73.5	0.68	69.09	0.49	42.75
8	1.17	47.21	0.53	73.5	0.85	61.36	0.51	40.39

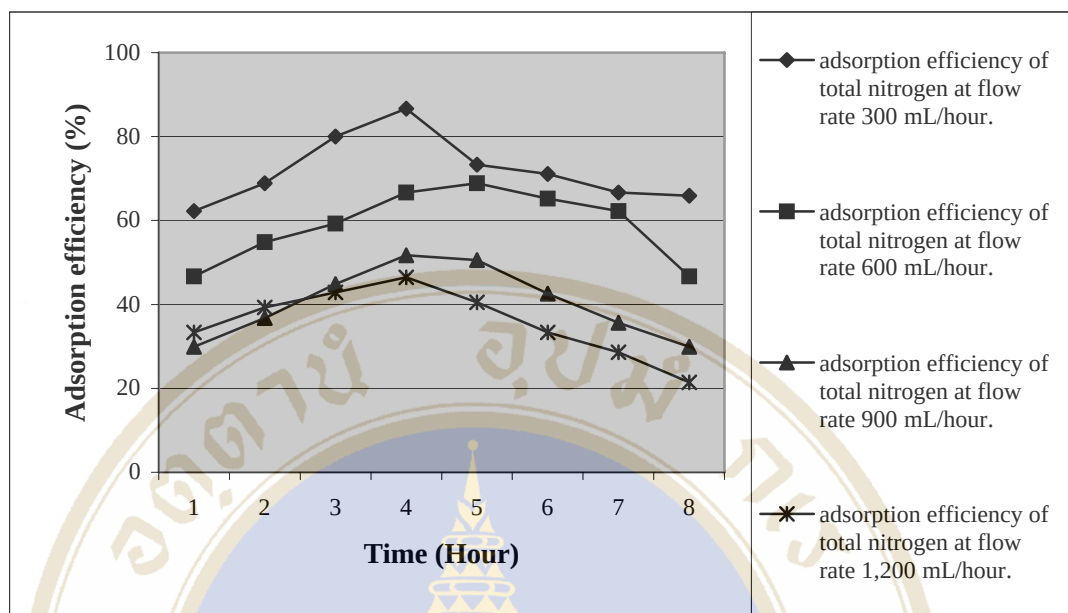


Figure 4-7 Efficiency of total nitrogen removing by 0.85 – 2.0 mm. burned blood cockle shell at different flow rate

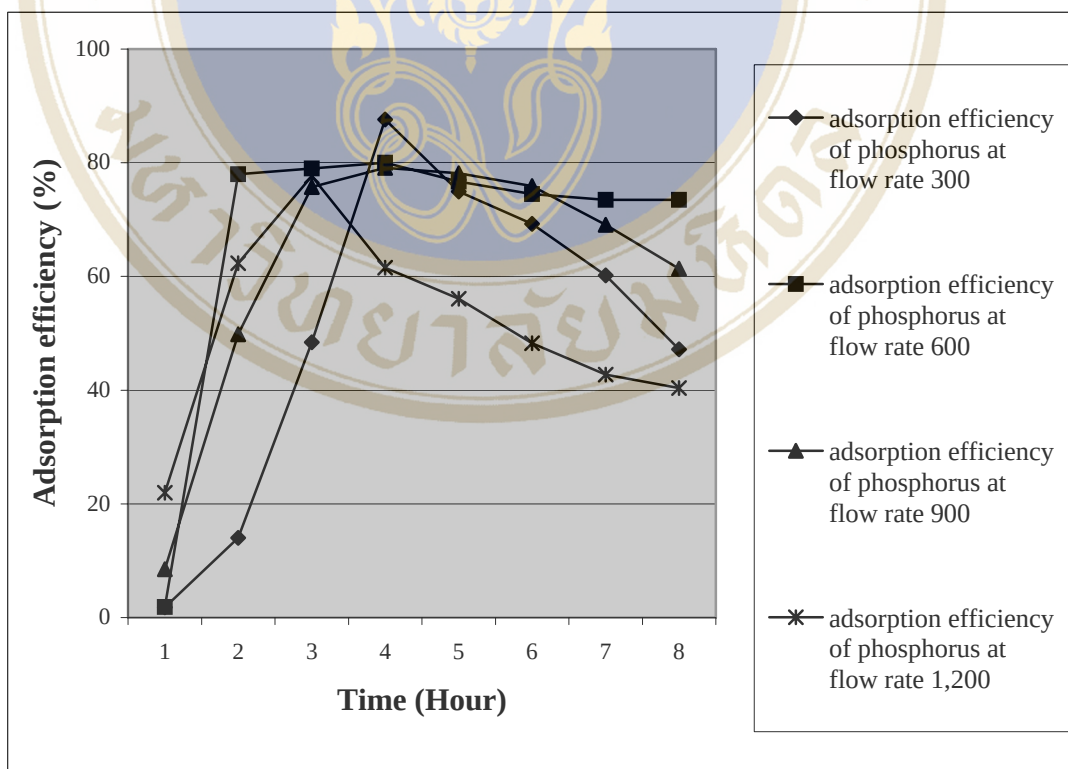


Figure 4-8 Efficiency of phosphorus removing by 0.85 – 2.0 mm. burned blood cockle shell at different flow rate

From figure 4-7 and 4-8 would see that the flow rate at 300 millimeter/hour that the burned blood cockle shells 0.85 - 2.0 millimeter sized had best effective in total nitrogen quantity reduction. Because of through 8 hours period time, the efficiency in total nitrogen quantity reduction was higher than the efficiency of total nitrogen reduction at another flow rate, but the efficiency in total nitrogen quantity reduction would increase during hour 4 first only. After that the efficiency of total nitrogen quantity reduction was down, which the rest of flow rate was at flow rate at 600 milliliters/hour, 900 milliliters/hour, and 1,200 milliliters/hour as be also, but the efficiency in nitrogen quantity reduction was down differently. By the efficiency in best total nitrogen quantity reduction was flow rate at 300 milliliters/hour, next below was flow rate at 600 milliliters/hour, and 900 milliliters/hour, respectively. And flow rate at 1,200 milliliters/hour that had worst efficiently in total nitrogen quantity reduction. The efficiency in phosphorus reduction found that the flow rates at 300 milliliters/hour to have increased effective in 4 hour first. Therefore it would steadily be down at flow rate 600 milliliters/hour. It had high efficiency in phosphorus quantity reduction for 4 hours first of the experiment. Thereafter, the efficiency would be quietly down at flow rate 900 milliliters/hour. The efficiency in phosphorus quantity reduction would increase quickly in 3 hours first and from hour 3 to hour 4 would increase a little. From that the efficiency would be quietly down as flow rate at 600 milliliters/hour. Flow rate at 1,200 milliliters/hour that would be height effective in phosphorus quantity reduction in 3 hours first also but thereafter the efficiency would be quickly down until experiment ending. From figure 4-8 indicate that the efficiency in the phosphorus increase quickly during hour 1-3.it maybe happen to increase start concentration of phosphorus then had impact on absorbent (7)

From the experiment result found that when flow rate was down. The burned blood cockle shell would have effective in phosphorus and total nitrogen quantity reduction more and more. Because of low flow rate made the period of time within column between the surface absorption material and phosphorus and total nitrogen in the effluent form shrimp farm for long time. The phosphorus and total nitrogen quantity quietly absorbed surface to pore size of burned blood cockle shell extremely. The height flow rate would has wider mass transfer zone, so affect of the period of time contact within column between the surface absorption materials and total

nitrogen and phosphorus were less. That was happen less surface absorption, thus the low flow rate had effective in the phosphorus and total nitrogen quantity reduction was better at height flow rate.

Therefore the best flow rate in the phosphorus and nitrogen quantity reduction were 300 milliliters/hour. They were flow rate in slow flow period and flow rate could decrease nitrogen quantity and phosphorus to standards line

4.3.3 Studying the total nitrogen and phosphorus reducing rates to be compared between burned blood cockle shell, natural blood cockle shell and activated charcoal at the best water flow rate.

From test 4.3.2 made to know that the best flow rate and had effective in the phosphorus and total nitrogen quantity reduction was flow rate at 300 milliliters/hour. Moreover, from 4.3.1 the best size of blood cockle shell had effective phosphorus and total nitrogen quantity reduction was 0.85 - 2.0 millimeter. Thus, the natural blood cockle shell take to use grinding in the same size with burned blood cockle shell was at 0.85 - 2.0 millimeter. The activated charcoal used in this test would have quality in absorbing the inorganic substance and must be without the phosphorus and the nitrogen too. So the activated charcoal was chose to use AR which non phosphorus and could organic absorption. Size of AR was 300 micron

The study result was burned blood cockle shells had best effective in total nitrogen quantity reduction at 86.66 percentages in hour 4. It had worst effective in total nitrogen quantity reduction at 62.22 percentages in hour 1. The best efficiency in phosphorus quantity reduction was 87.78 percentages in hour 4 and worst efficiency in phosphorus quantity reduction was 1.81 percentages in hour 1. The efficiency of natural blood cockle shells was the best efficiency in the total nitrogen reduction to be 31.71 percentages in hour 4 - 6 and the worst efficiency in total nitrogen quantity reduction was 4.88 percentages in hour 1. The best efficiency in phosphorus quantity reduction was 57.7 percentages in hour 3 and the worst efficiency in phosphorus reduction quantity was 33.83 percentages in hour 8. The activated charcoal had small-sized 0.03 millimeter. The experiences time happen was blockading, so can experiment just hour 4 first only. The result was the best efficiency in total nitrogen reduction was 75 percentages at hour 3-4 and the worst efficiency in

the total nitrogen reduction was 58.33 percentages at hour 1. The best efficiency the phosphorus quantity was 83.26 percentages at hour 4 and worst efficiency in phosphorus quantity reduction was 79.19 percentages at hour 1. They were as followed on tables 4-7 and 4-8.

Table 4-7 Efficiency of removal total nitrogen by 0.85 – 2.0 mm. burned blood cockle shell at different flow rate, natural blood cockle shell and activated charcoal

Time (Hour)	Burned blood cockle shell		Natural blood cockle shell		Activated charcoal	
	Concentration (mg-N/L)	Efficiency (%)	Concentration (mg-N/L)	Efficiency (%)	Concentration (mg-N/L)	Efficiency (%)
0	12.6	-	11.48	-	10.08	-
1	4.76	62.22	10.92	4.88	4.2	58.33
2	3.92	68.88	10.08	12.19	3.36	66.66
3	2.52	80	9.24	19.51	2.52	75
4	1.68	86.66	7.84	31.71	2.52	75
5	3.36	73.33	7.84	31.71	-	-
6	3.64	71.11	7.84	31.71	-	-
7	4.2	66.66	8.12	29.27	-	-
8	4.2	66.66	9.24	19.51	-	-

Table 4-8 Efficiency of removal phosphorus by 0.85 – 2.0 mm. burned blood cockle shell at different flow rate, natural blood cockle shell and activated charcoal

Time (Hour)	Burned blood cockle shell		Natural blood cockle shell		Activated charcoal	
	Concentration (mg-P/L)	Efficiency (%)	Concentration (mg-P/L)	Efficiency (%)	Concentration (mg-P/L)	Efficiency (%)
0	2.21	-	2.01	-	2.21	-
1	2.17	1.81	1.08	46.27	0.46	79.19
2	1.87	15.38	1.08	46.27	0.44	80.09
3	1.7	23.08	0.85	57.7	0.41	81.44
4	0.27	87.78	1.14	43.28	0.37	83.26
5	0.28	87.33	1.23	38.8	-	-
6	0.32	85.52	1.23	38.8	-	-
7	0.81	63.35	1.23	38.8	-	-
8	1.54	30.31	1.33	33.83	-	-

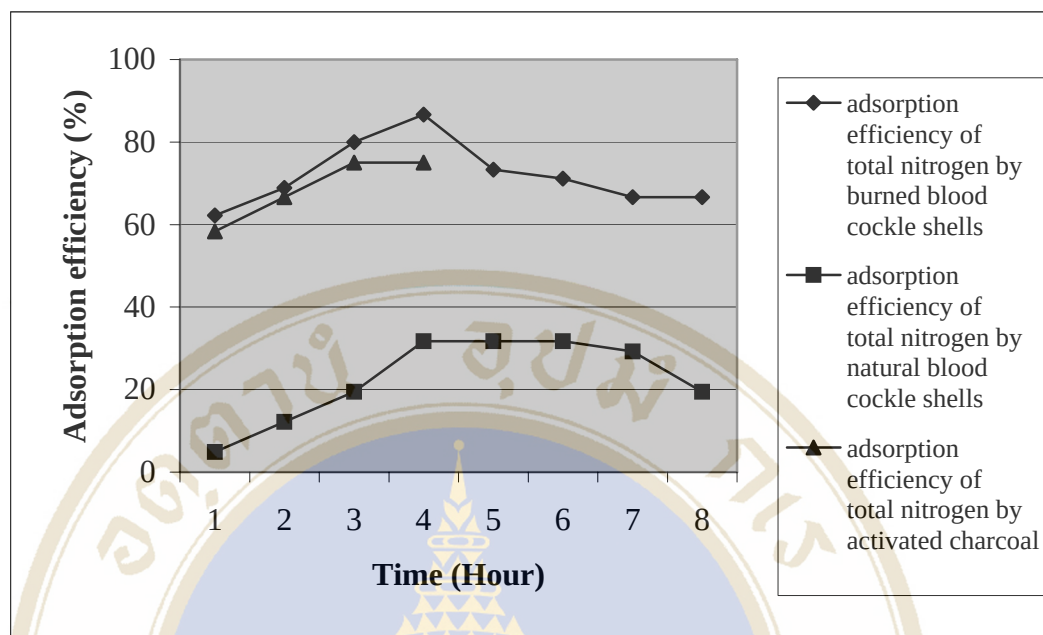


Figure 4-9 Efficiency of removal total nitrogen by 0.85 – 2.0 mm. burned blood cockle shell at different flow rate, natural blood cockle shell and activated charcoal

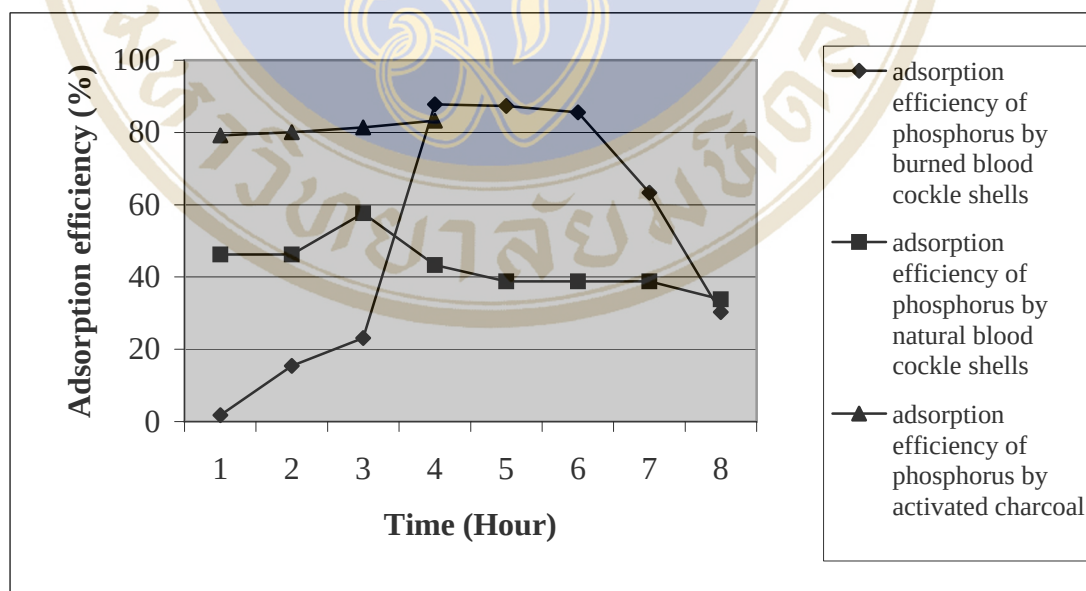


Figure4-10 Efficiency of removal phosphorus by 0.85 – 2.0 mm. burned blood cockle shell at different flow rate, natural blood cockle shell and activated charcoal

From figure 4-9 and 4-10 indicated that the burned blood cockle shells had effective in total nitrogen quantity reduction be better than natural blood cockle shells and activated charcoal. The effective of total nitrogen reduction was increase continuously during hour 4 first. From that would quietly be down until the experiment end. The activated charcoal had effective in total nitrogen quantity reduction increase continuously also but because of the activated charcoal that could not do the experiment in next other hours. So, it could not know the tendency of the efficiency total nitrogen quantity reduction. The burned blood cockle shells had effective in total nitrogen quantity reduction to increase 4 hour first time. From that would be down continuously until the experimental ending also. For the efficiency in the phosphorus reduction that the burned blood cockle shells had best effective. The efficiency in reduction would increase quickly in hour 4. After that it would quietly be down until hour 6 ago then would be down quickly. The activated charcoal had effective in phosphorus reduction to increases continuously in 4 hour first but because of could not do experiment continually, then could not know the efficiency in next hour. The natural blood cockle shells had effective in phosphorus reduction during hour 1-3 was better than burned blood cockle shells but after that the efficiency was down continuously until the experiment ends.

From the experiment found that the burned blood cockle shells had effective in the phosphorus and total nitrogen quantity reduction better than the natural blood cockle shells. Because of burned blood cockle shells had BET surface area more than natural blood cockle shells, moreover it had big pore size more, then it had effective in total nitrogen reduction quantity and the phosphorus better. Next, it was natural blood cockle shells.

4.4 Absorption Isotherm

The experimental data were calculated to determine the absorption isotherm using the langmuir and freundlich model. In this study both models were applied to describe the relationship between the amount of nitrogen and phosphorus absorbed and burned blood cockle shell.

The absorption material study was burned blood cockle shells 0.85 - 2.0 mm sizes, intensity of the total nitrogen 1 mg-nitrogen, 5 mg-nitrogen, 10 mg-nitrogen,

and 15 mg-nitrogen. Intensity of the phosphorus that used 1 mg-phosphorus, 5 mg-phosphorus, 10 mg-phosphorus, and 15 mg-phosphorus. When the researchers do the experiment would mix the nitrogen and the phosphorus together. Flow rate used at 300 a milliliter /hour. The time that used 8 hours, unadjusted pH. The quantity of burned blood cockle shells used to be 2.7 kilogram. The result is shown in Table 4-9 and 4-10.



Table 4-9 Efficiency of total nitrogen removing by 0.85 – 2.0 mm. burned blood cockle shell at different total nitrogen concentrate

Time (Hour)	Total Nitrogen					
	Concentration (mg-N/L)	Efficiency (%)	Concentration (mg-N/L)	Efficiency (%)	Concentration (mg-N/L)	Efficiency (%)
0	1	-	5	-	10	-
1	0.84	16	4.2	16	7.84	21.6
2	0.56	44	3.64	27.2	7.56	24.44
3	0.28	72	3.08	38.4	7	30
4	0.28	72	2.52	49.6	6.72	32.8
5	0.28	72	2.24	55.2	5.32	46.8
6	0.56	44	2.52	49.6	6.44	35.6
7	0.56	44	4.2	16	7.84	21.6
8	0.84	16	3.64	27.2	7.56	24.44
					0.24	98.4

Table 4-10 Efficiency of phosphorus removing by 0.85 – 2.0 mm. burned blood cockle shell at different phosphorus concentrate

Time (Hour)	Phosphorus					
	Concentration (mg-N/L)	Efficiency (%)	Concentration (mg-N/L)	Efficiency (%)	Concentration (mg-N/L)	Efficiency (%)
0	1	-	5	-	10	-
1	0.91	9	0.14	97.2	0.34	96.6
2	0.9	10	0.12	97.6	0.32	96.8
3	0.86	14	0.12	97.6	0.16	98.4
4	0.16	84	0.12	97.6	0.13	98.7
5	0.12	88	0.11	97.8	0.11	98.9
6	0.12	88	0.12	97.6	0.11	98.9
7	0.12	88	0.12	97.6	0.12	98.8
8	0.14	86	0.13	97.4	0.13	98.7
					0.24	98.4
					0.18	98.8
					0.17	98.86
					0.12	99.2
					0.48	96.8
					0.58	96.13
					1.14	92.4
					1.15	92.33
					15	-

From Langmuir equation

By
$$q = \frac{q_m K_A C}{1 + K_A C} \quad (2.1)$$

$$\frac{C}{q} = \frac{1}{K_A q_m} + \frac{C}{q_m} \quad (2.2)$$

$$\frac{1}{q} = \frac{1}{q_m} + \frac{(1)}{K_A q_m} \frac{1}{C} \quad (2.3)$$

where ;

Q	=	Substance quantity per adsorption weight
Q_m	=	Substance quantity per adsorption weight for complete monolayer
C	=	Concentrate of solute at equilibrium point
K_a	=	The state of adsorption heat

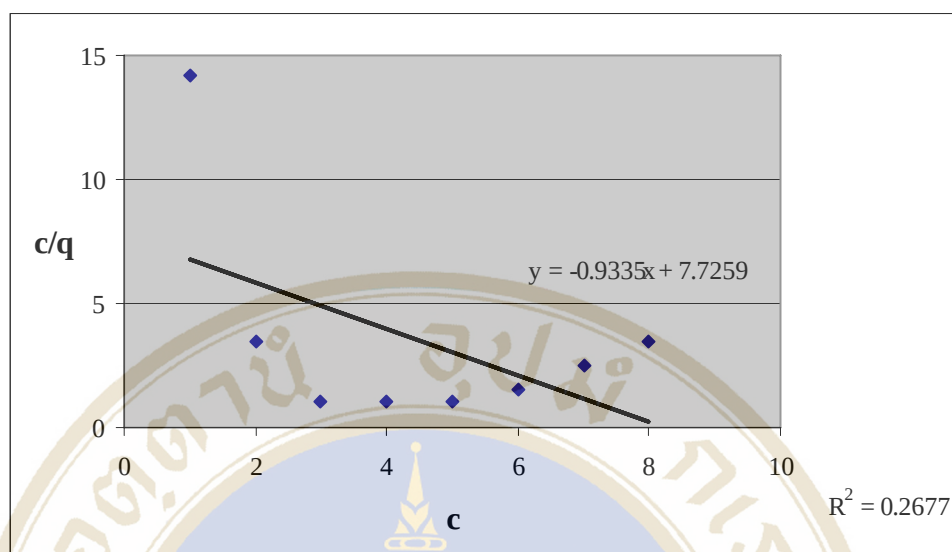


Figure 4-11 Langmuir absorption isotherm for 1mg-N/L total nitrogen removing by 0.85 – 2.0 mm. burned blood cockle shell

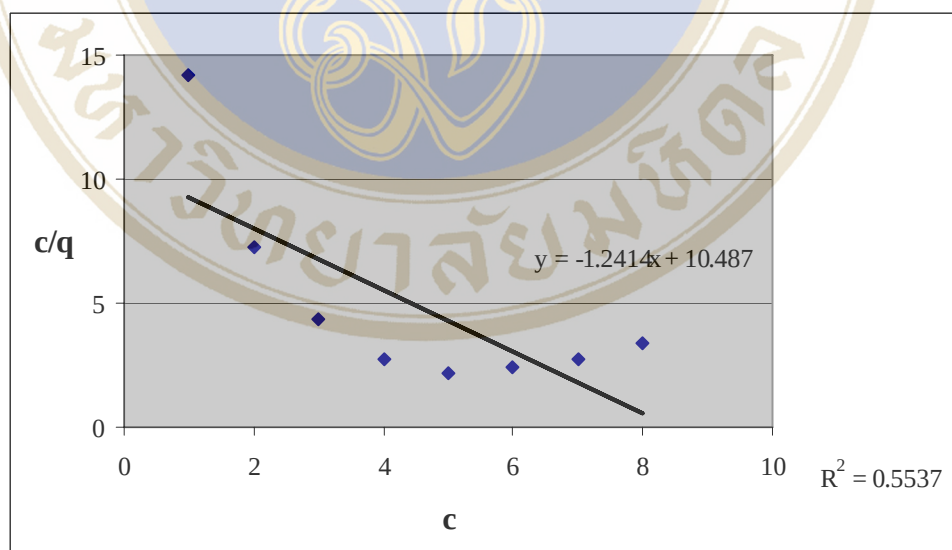


Figure 4-12 Langmuir absorption isotherm for 5 mg-N/L total nitrogen removing by 0.85 – 2.0 mm. burned blood cockle shell

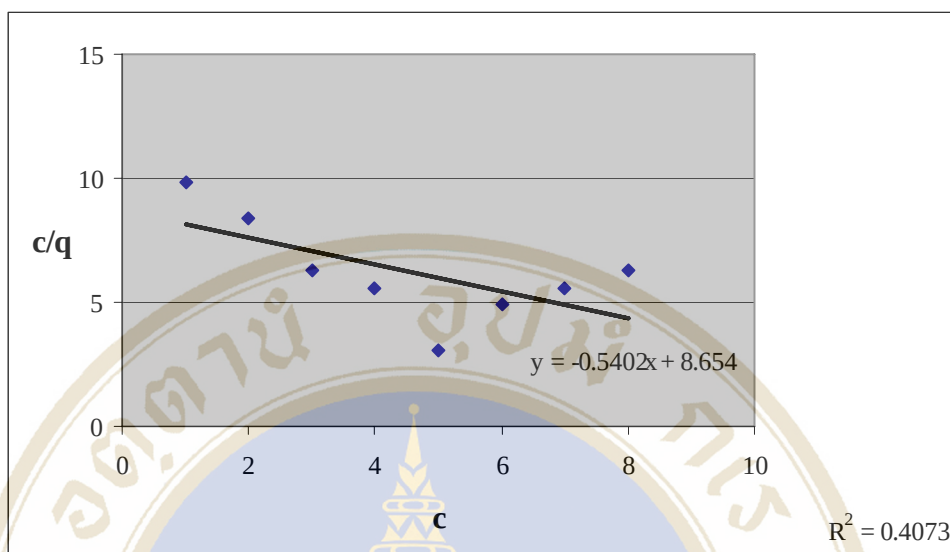


Figure 4-13 Langmuir absorption isotherm for 10 mg-N/L total nitrogen removing by 0.85 – 2.0 mm. burned blood cockle shell

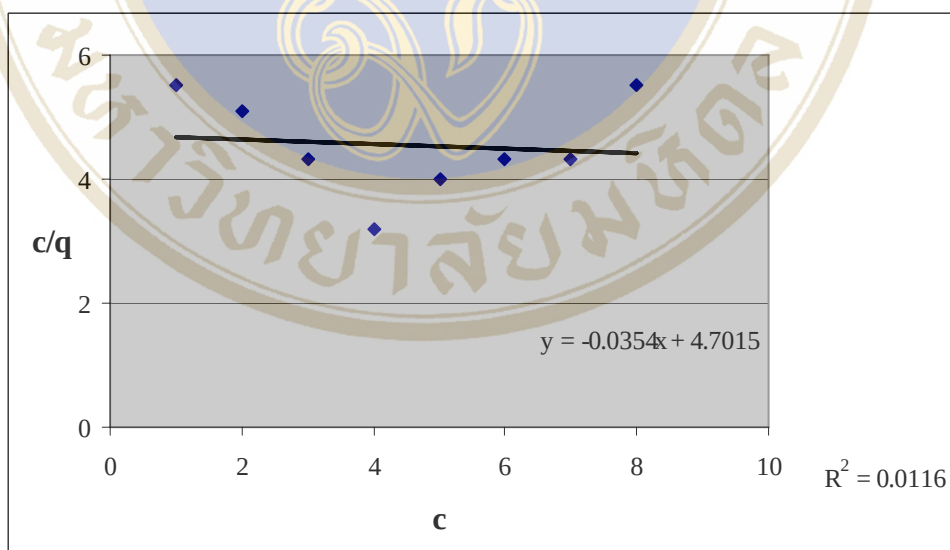


Figure 4-14 Langmuir absorption isotherm for 15 mg-N/L total nitrogen removing by 0.85 – 2.0 mm. burned blood cockle shell

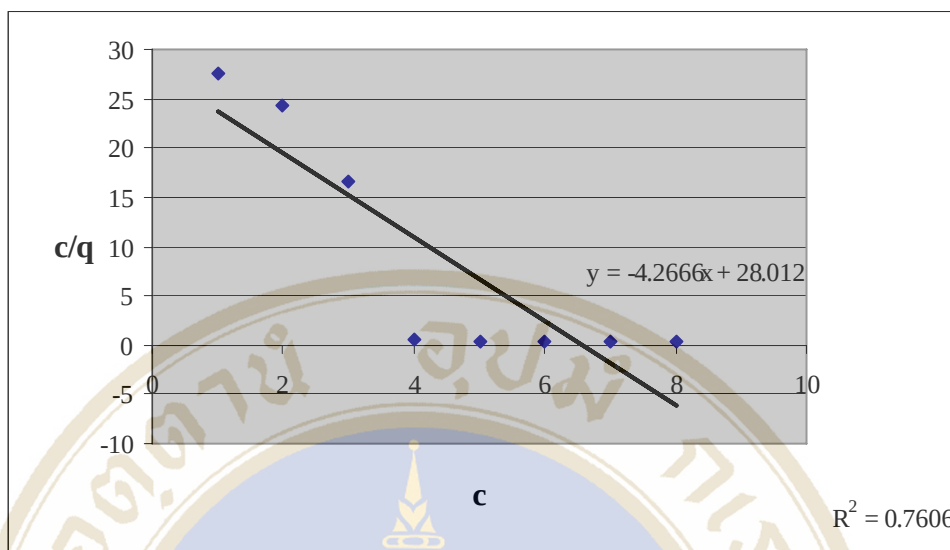


Figure 4-15 Langmuir absorption isotherm for 1 mg-P/L phosphorus removing by 0.85 – 2.0 mm. burned blood cockle shell

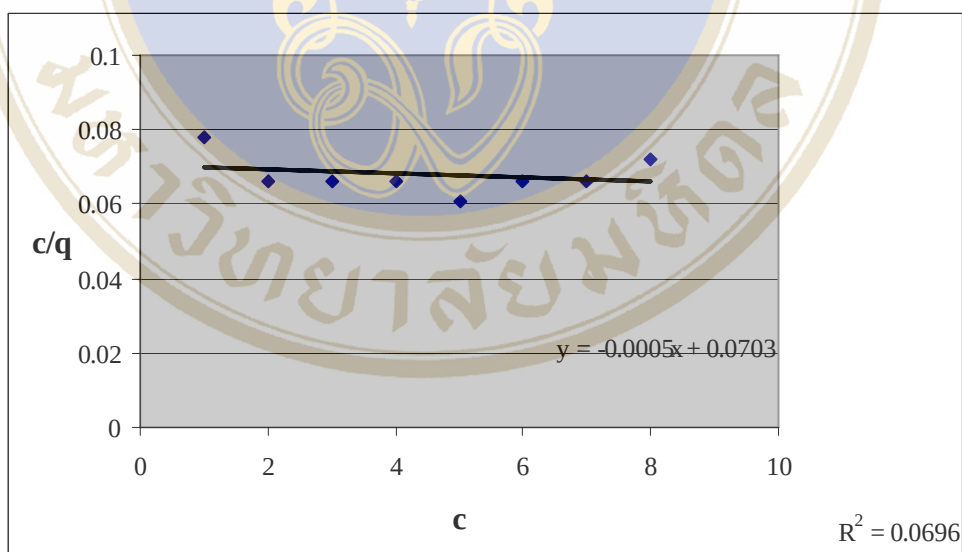


Figure 4-16 Langmuir absorption isotherm for 5 mg-P/L phosphorus removing by 0.85 – 2.0 mm. burned blood cockle shell

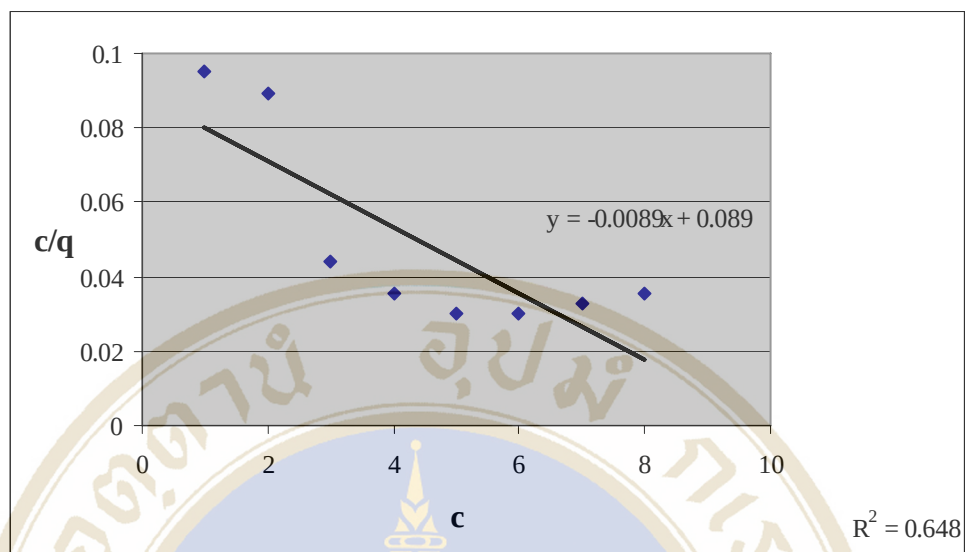


Figure 4-17 Langmuir absorption isotherm for 10 mg-P/L phosphorus removing by 0.85 – 2.0 mm. burned blood cockle shell

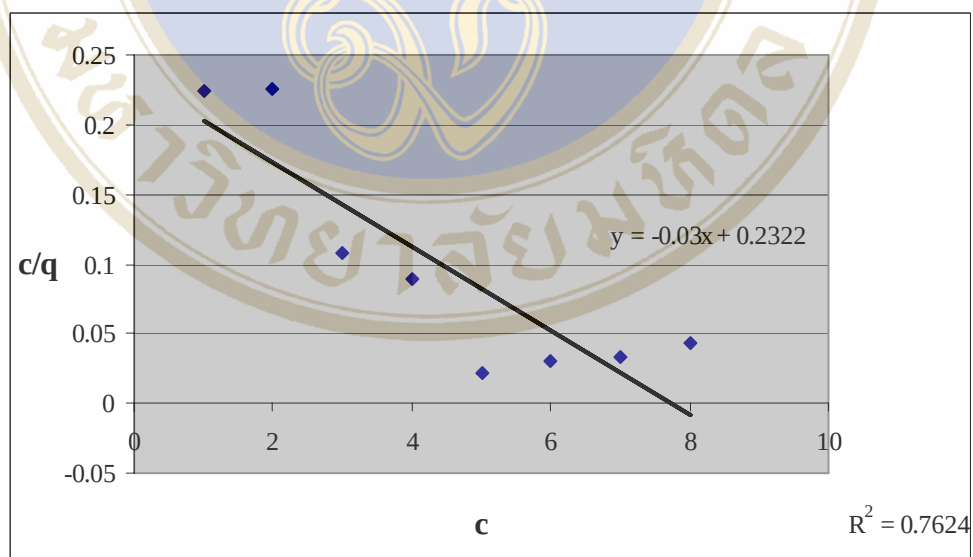


Figure 4-18 Langmuir absorption isotherm for 15 mg-P/L phosphorus removing by 0.85 – 2.0 mm. burned blood cockle shell

Form Freundlich equation

$$\frac{X}{M} = K_F C^{1/n}$$

$$\text{or} \quad \log \frac{X}{M} = \log K_F + \frac{1}{n} \log C$$

Where; X = Quantity of solute which has been adsorbed

M = Weight of adsorption

C = Concentrate of solute at equilibrium point

K_F and N is stable value which will depend on the temperature of adsorption substance

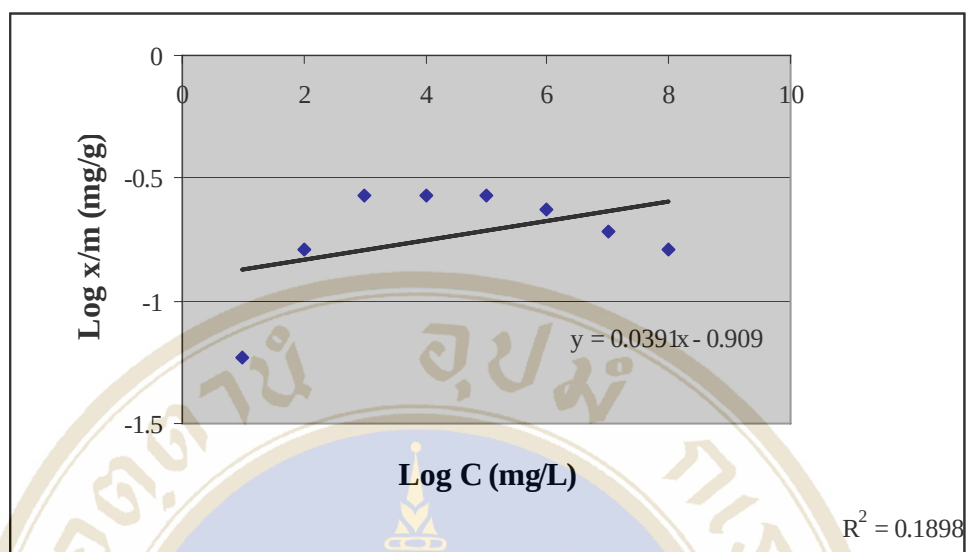


Figure 4-19 Freundlich absorption isotherm for 1mg-N/L total nitrogen removing by 0.85 – 2.0 mm. burned blood cockle shell

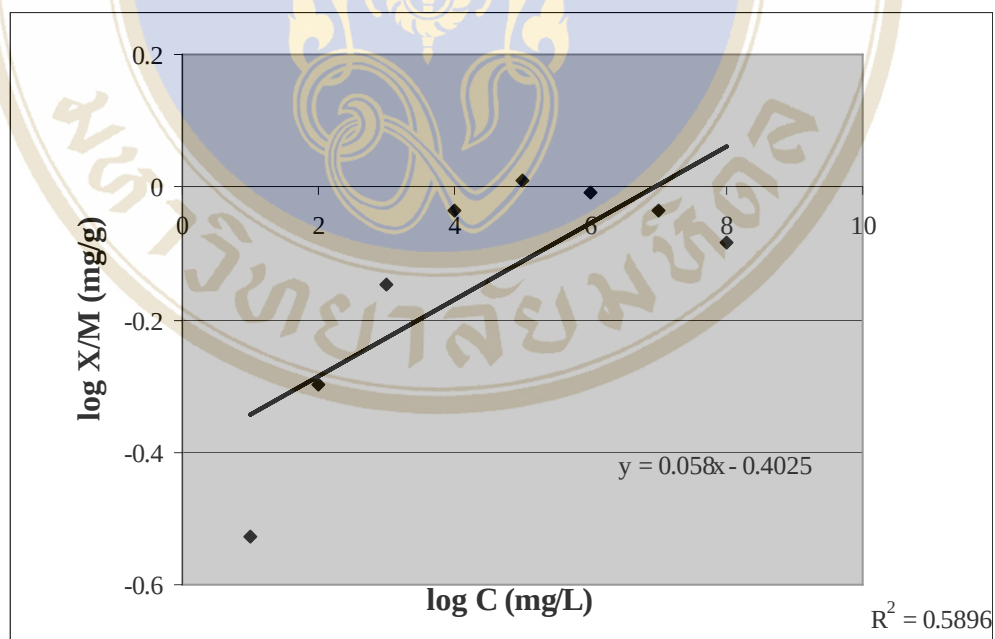


Figure 4-20 Freundlich absorption isotherm for 5mg-N/L total nitrogen removing by 0.85 – 2.0 mm. burned blood cockle shell

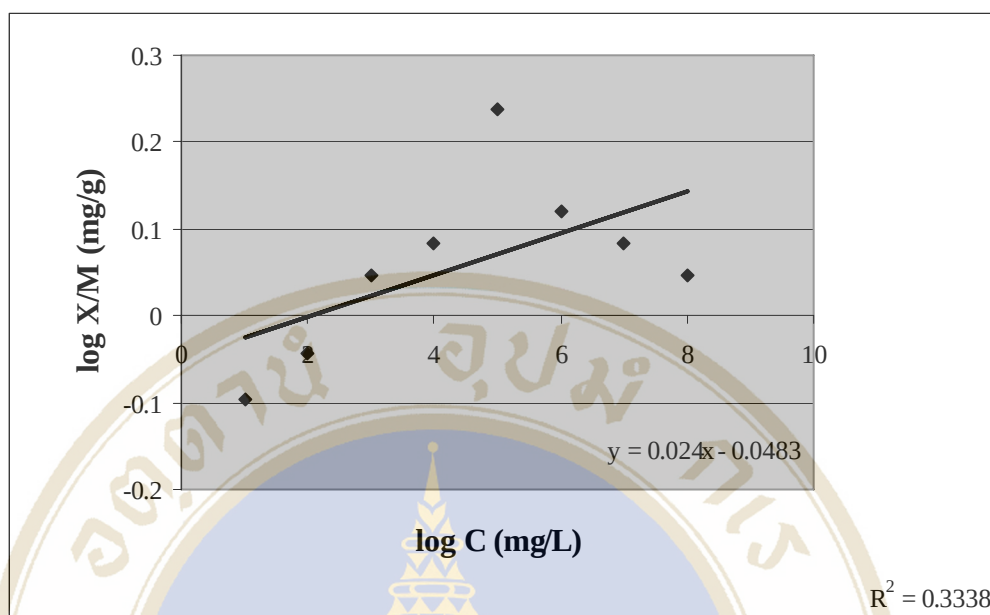


Figure 4-21 Freundlich absorption isotherm for 10 mg-N/L total nitrogen removing by 0.85 – 2.0 mm. burned blood cockle shell

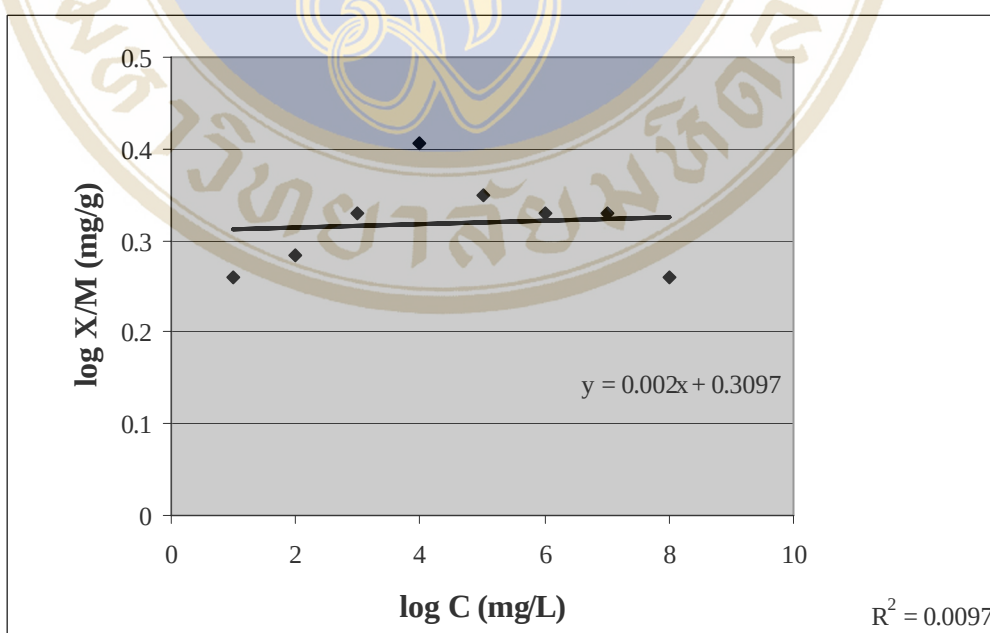


Figure 4-22 Freundlich absorption isotherm for 15 mg-N/L total nitrogen removing by 0.85 – 2.0 mm. burned blood cockle shell

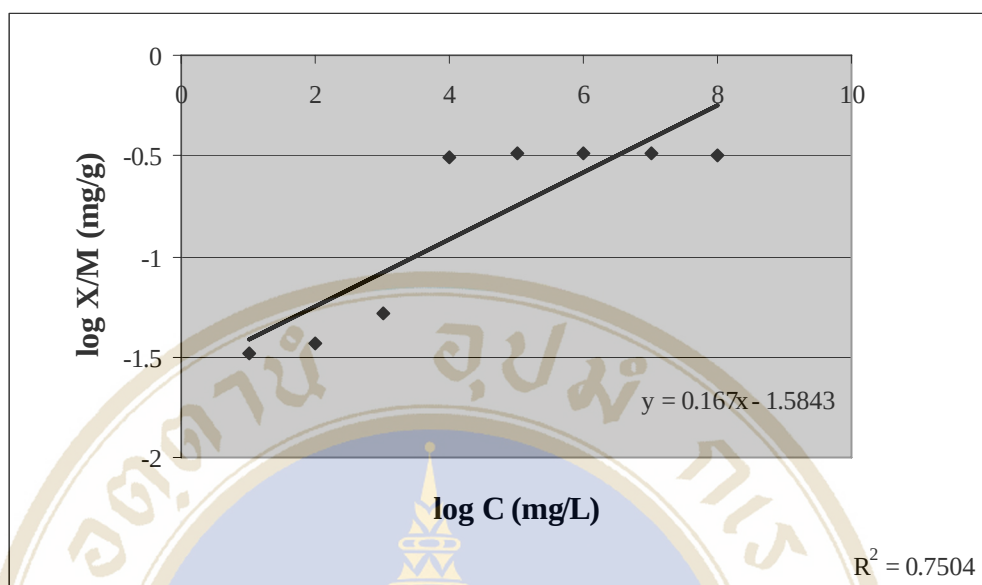


Figure 4-23 Freundlich absorption isotherm for 1 mg-P/L phosphorus removing by 0.85 – 2.0 mm. burned blood cockle shell

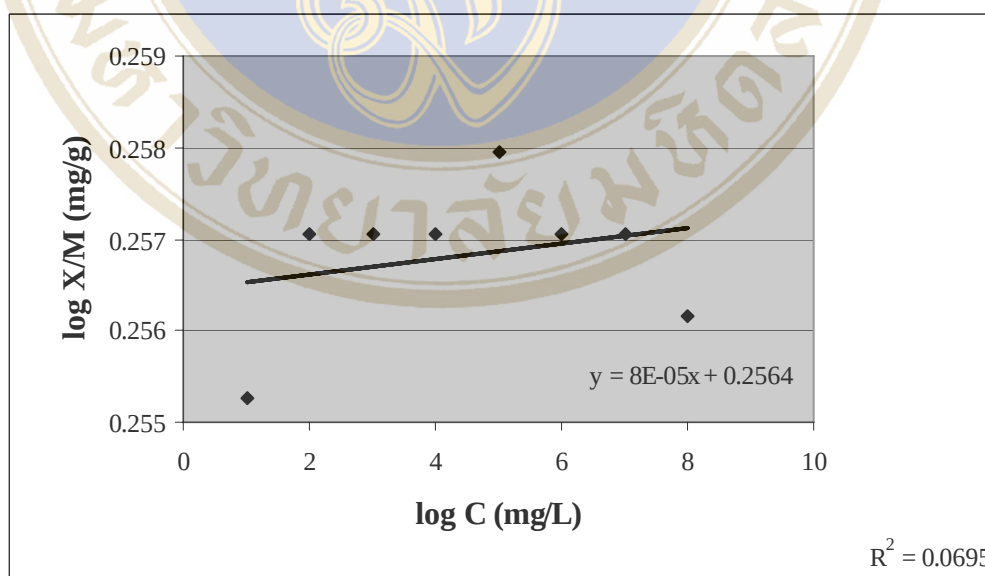


Figure 4-24 Freundlich absorption isotherm for 5 mg-P/L phosphorus removing by 0.85 – 2.0 mm. burned blood cockle shell

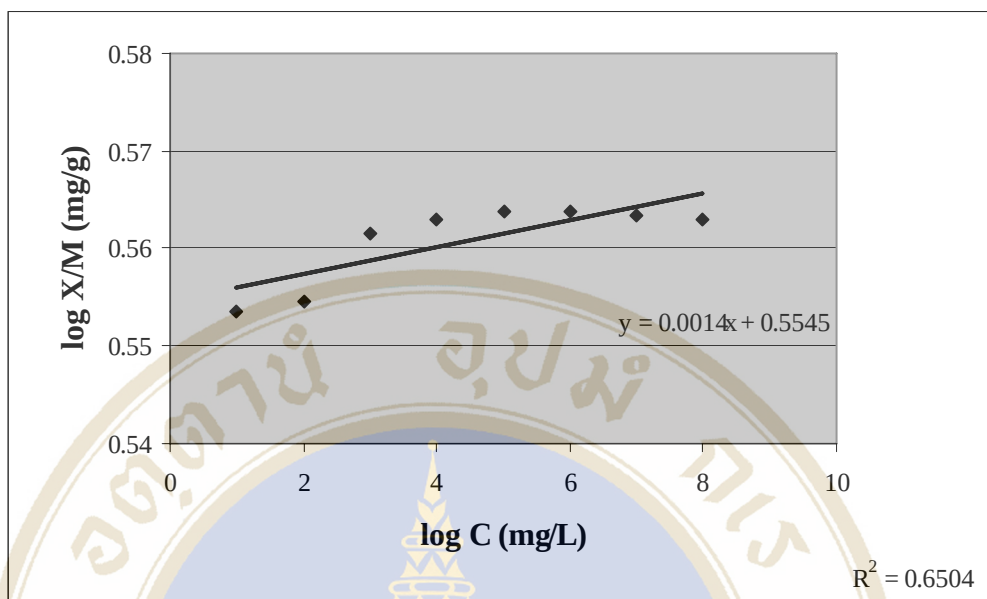


Figure 4-25 Freundlich absorption isotherm for 10 mg-P/L phosphorus removing by 0.85 – 2.0 mm. burned blood cockle shell

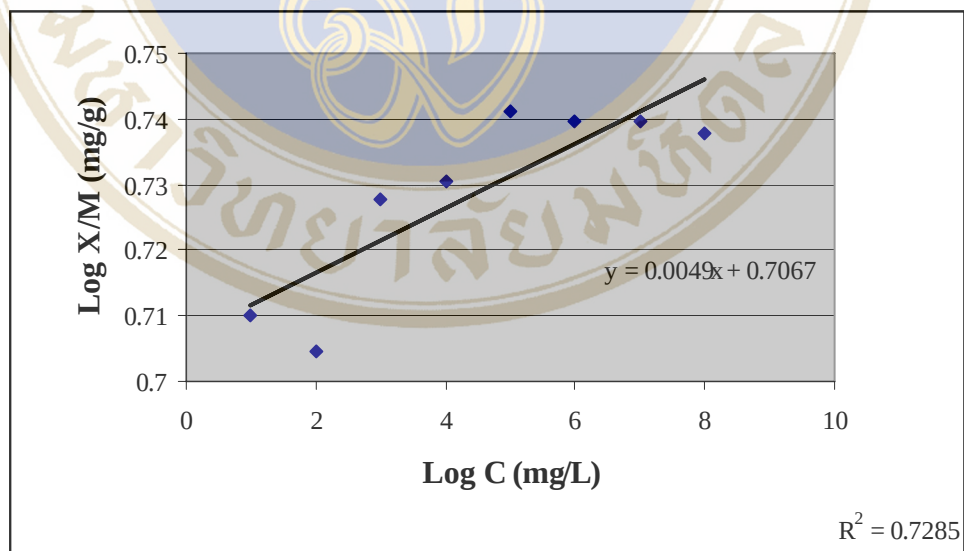


Figure 4-26 Freundlich absorption isotherm for 15 mg-P/L phosphorus removing by 0.85 – 2.0 mm. burned blood cockle shell

from figure 18 – 33 can to be count constants of Langmuir equation is Q_m and K_a and Freundlich equation is K and $1/n$. The result is the following this table.

Table 4-11 Constants for total nitrogen and phosphorus with 4 concentration of total nitrogen and phosphorus

	Concentrate (mg/L)	Langmuir model			Freundlich model		
		Q_m	K_a	R^2	$1/n$	K	R^2
Total Nitrogen	1	-1.0712	-0.1208	0.2677	0.0391	0.1233	0.1898
	5	-0.8055	-0.1184	0.5537	0.058	0.3958	0.5896
	10	-1.8512	-0.0624	0.4073	0.024	0.8947	0.3338
	15	-28.2486	-0.0075	0.0116	0.002	2.0403	0.0097
Phosphorus	1	-0.2344	-0.1523	0.7606	0.167	0.0260	0.7504
	5	-2000	-0.0071	0.0696	0.00008	1.8047	0.0695
	10	-112.359	-0.1	0.648	0.0014	3.5851	0.6504
	15	-33.333	-0.1292	0.7624	0.0049	5.0898	0.7285

The results are shown in table 4-11 which indicated that the Langmuir equation were fitted to the data with the least square fit (R^2) of 1, 5, 10 and 15 mg-N/L and 1, 5, 10 and 15 mg-P/L were 0.2677, 0.5537, 0.4073 and 0.0116, 0.7606, 0.0696, 0.648 and 0.7624 respectively. For the Freundlich equation, the value of R^2 of 1, 5, 10 and 15 mg-N/L and 1, 5, 10 and 15 mg-P/L were 0.1898, 0.5896, 0.3338 and 0.0097, 0.7504, 0.0695, 0.6504 and 0.7285 respectively

In our experimental ranges, the results of 4 concentration of total nitrogen and phosphorus tended to be described by the Langmuir model, because the regression line obtained from the Langmuir curve tended to be fit better than the Freundlich curve.

From the table could explain to compare the ability in absorbing between total nitrogen and the phosphorus of burned blood cockle shells by Q_m and K_a value of phosphorus absorption was higher than total nitrogen absorbing. It shown that burned blood cockle shells to have the capability in phosphorus absorption better than total nitrogen absorption when was used in the equal quantity. But K_a value and $1/n$ value had less than 1 then to perform quantity of absorbent was a few absorption.

CHAPTER V

CONCLUSION AND SUGGESTION

5.1 The research conclusion

From the case study for decreasing phosphorus and total nitrogen quantity in the effluent from shrimp farm by using burned blood cockle shells. The researcher got doing the experiment is 4 the steps including analyze physical character of burned blood cockle shells, tested efficiency with nitrogen and phosphorus quantity reduction that cockle shells were different size and flow rate reaches different column, studied to compare efficiency with total nitrogen quantity reduction and the phosphorus between burned blood cockle shells, natural blood cockle shells, and activated charcoal at best flow rate and studied absorption isotherm. The researcher could conclude the research has as follows.

This study was physical absorption. Because of burn blood cockle shells had carbonate calcium was important element around 60 - 80 percentages of weight. From physical analysis by Gas Sorption Analyzer by using Bunauer, Emmett, and Teller method (BET) and study of surface character and riddled hole of burn blood cockle shells by use Scanning Electron Microscopy (SEM) found that had a lot of riddled holes, which the factor was absorbing affect. The surface area was quality to have affect in molecular ability that absorbed in absorption, that was the ability in absorption would increase when surface area of molecular which was absorption more over and the structure of riddled hole support surface area had ability in absorption more over also. The isotherm absorbing study from the equation Langmuir by use synthetic effluent that had intensity 1, 5, 10 and 15 milligrams/liter, found that, burned blood cockle shell size 0.85 - 2.0 millimeter that could decrease phosphorus quantity better than total nitrogen which considered from Q_m , and K_a and Freundlich equation by using synthetic effluent that had intensity 1, 5, 10 and 15 milligrams/liter

found that, burned blood cockle shell size 0.85 - 2.0 millimeter that could decrease phosphorus quantity better than total nitrogen too which considered from K, and 1/n.

From tables 4-2 and figures 4-1 to 4-3 would see obviously when brought burned blood cockle shells and natural blood cockle shells compare together. The burned blood cockle shells had touches surface area more than natural blood cockle shells and burned blood cockle shells had hole riddled size bigger than natural blood cockle shell. So the absorption efficiency was different. From efficiency comparison of the phosphorus and total nitrogen quantity reduction between burned blood cockle shells, natural blood cockle shell that had different size, and activated charcoal at the flow rate found that the burned blood cockle shells had effective in the phosphorus and totals nitrogen quantity reduction better than natural blood cockle shells because of the physical character that inform in the beginning. The activated charcoal was done the education just only 4 hours. However, the result that for the nitrogen totals had effective less than burned blood cockle shells. The phosphorus had effective similarly. From figure 4-4 could see obviously that occurred the physical absorbing react (Physical Adsorption) because of had several crystal cling on surface area of cockle shells.

The cockle shell size that used in studying about material size (particle size). When the researcher lead the study of cockle shell both of 2 size shells to compared, researched that, burned blood cockle shells at the 0.85–2.0 millimeter size that efficiency in the phosphorus and nitrogen quantity reduction was better than the size of burned blood cockle shells that bigger than 2.0 millimeters. The best efficiency of burned blood cockle shells at 0.85–2.0 millimeter size in the phosphorus and total nitrogen quantity reduction was 86.66 and 87.63 percentages. Moreover burned blood cockle shell that large-sized more 2.0 millimeters had effective in the phosphorus and total nitrogen quantity reduction was 70.23 and 77.53 percentages respectively. Because of the absorption molecular had a lot of pore sizes. The surface area that used absorption would be in riddled hole.

From efficiency test about the nitrogen and phosphorus quantity reduction at flow rate reached different column, met that, at flow rate 300 a milliliter / hour had the most effective in the phosphorus and total nitrogen quantity reduction which had effective 86.66 and 87.63 percentages. Because of this flow rate was slow flow rate

to make the period of touch time within the column between burned blood cockle shells, the total nitrogen and the phosphorus in the effluent from shrimp farm was long. The phosphorus and total nitrogen quantity quietly absorbed into riddled hole of burned blood cockle shells extremely. The high flow rate would make wider ventilating mass which would make the period of contact time within the column between the surface absorbable material, the nitrogen total up, and the phosphorus was less. To make surface absorption was less. Thus, at low flow rate had effective in the phosphorus and total nitrogen quantity reduction was better at high flow rate.

When brought the experiment to compare with other research result that used absorption, found that the cockle shells could decrease nitrogen quantity better than treating from the oxygen added pond by chemical precipitate (28). However, ability in phosphorus quantity reduction that cockle shells had effective inferior than treating from oxygen added pond by chemical precipitate just a little. When compared with eliminating nitrogen and phosphorus in effluent from throng area by used the seaweed (26), found that the seaweed *Uronema sp.* could eliminate nitrogen and phosphorus just 72.17 percentages in 10 day and 34.24 percentages in 12 day, which the burned blood cockle shells had effective in eliminating better.

However, when compared between burned blood cockle shells and filtration system directly by using the filters sand and antacite in phosphorus quantity reduction (27) found that the filtration system directly used the filters sand and antacite that was effective better than using burned blood cockle shells. Moreover, eliminating phosphorus used Concrete waste (29) that was more effective also. The phosphorus eliminating in synthetic effluent used the iron sieve (7) was less effective than using burned blood cockle shells. Comparison between burned blood cockle shells and oysters in the phosphorus quantity reduction (5), found that the burned blood cockle shells at 750°C temperatures could eliminate the phosphorus better than burned oyster shells at 750°C temperatures. But they were less effective than the burned oyster shells 750°C at temperatures under the atmosphere that had the nitrogen. When compared nitrogen eliminating between burned blood cockle shells and nitrification procedure (30), found that the nitrification procedure was more effective than using burned blood cockle shells in absorption.

Burned blood cockle shell could remove total nitrogen and phosphorus from shrimp farm effluent. In fact, temperature use in laboratory could not to take it but when blood cockle shell to burned at other temperature, it had increase more pores which could it the same. When compared with other materials, blood cockle shell could easy to found, cheap and appropriate for the medium quantity of shrimp farm effluent. In addition, it could reduce chemical residues operation cost, and possible to recycle of waste or by-product.

5.2 Suggestion

5.2.1 To do the extra experiences by adding the size of the column bigly or enlarge height of cockle shell for increasing efficiency in the phosphorus and total nitrogen quantity reduction.

5.2.2 To study the efficiency in the phosphorus and total nitrogen reduction by using other material which had chemistry quality was like the burned blood cockle shells for being the choice in effluent treat from shrimp farm next.

5.2.3 To study about a method to reduce pH and the hardness that was treated to take some water to comes back for using next.

5.2.4 To analysis ammonia nitrate and nitrite before and after test for study use recycle water in shrimp farm

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APPENDIX A

BURNED BLOOD COCKLE SHELL AND NATURAL BLOOD COCKLE SHELL



Figure A-1 natural blood cockle shell

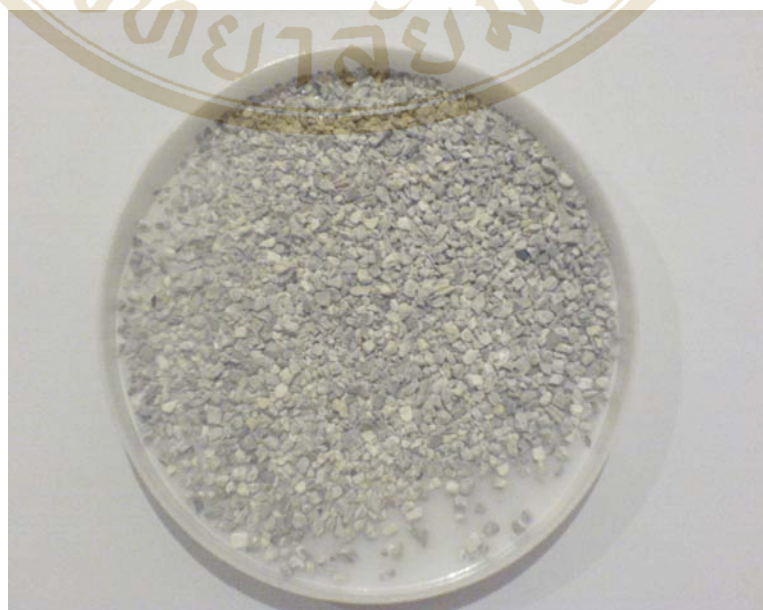


Figure A-2 0.85 - 2.0 mm. Burned blood cockle shell



Figure A-3 large-sized more 2.0 mm. burn blood cockle shell



Figure A-4 0.85 - 2.0 mm. natural blood cockle shell

APPENDIX B

STATISTICAL ANALYSIS

Effect of Size Burned blood cockle shell

Descriptives									
		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
N	Small size	8	71.8475	8.03702	2.84151	65.1284	78.5666	62.22	86.66
	Large size	8	50.5938	16.27165	5.75290	36.9903	64.1972	28.57	70.23
	Total	16	61.2206	16.55780	4.13945	52.3976	70.0437	28.57	86.66
P	Small size	8	50.4338	29.61017	10.46878	25.6790	75.1885	1.81	87.63
	Large size	8	65.1775	8.67558	3.06728	57.9245	72.4305	53.55	77.53
	Total	16	57.8056	22.41087	5.60272	45.8637	69.7475	1.81	87.63

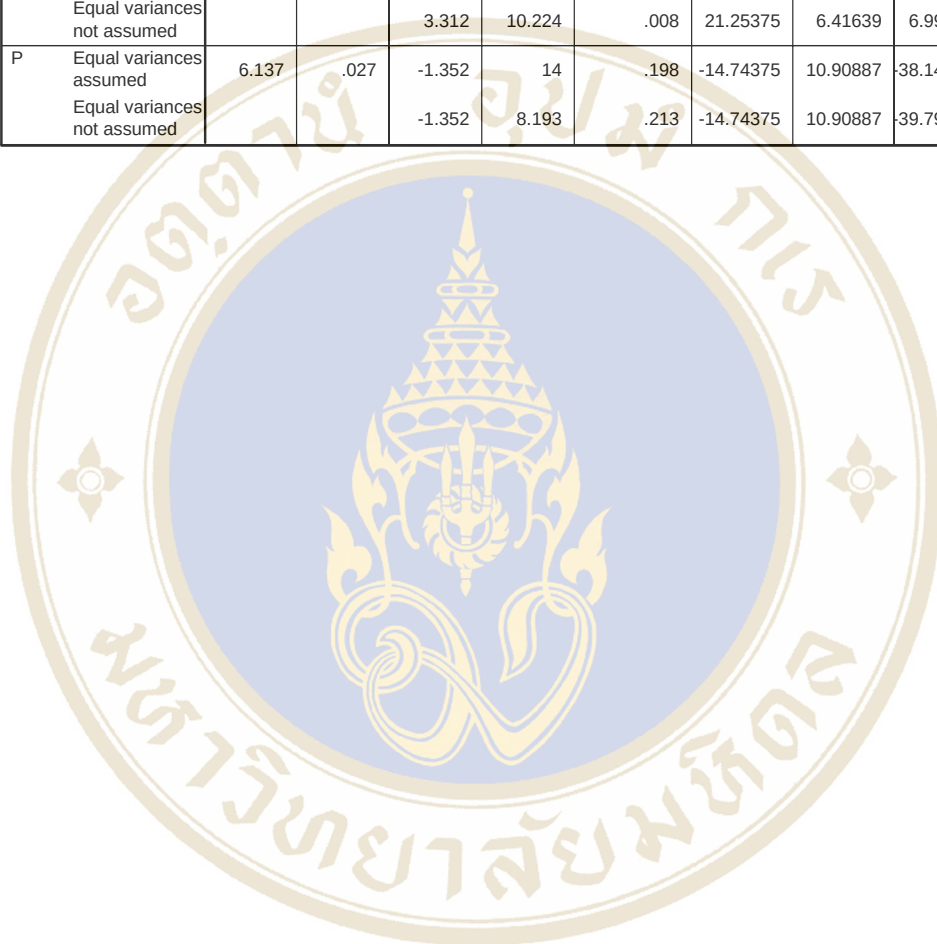
ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
N	Between Groups	1806.888	1	1806.888	10.972	.005
	Within Groups	2305.521	14	164.680		
	Total	4112.409	15			
P	Between Groups	869.513	1	869.513	1.827	.198
	Within Groups	6664.196	14	476.014		
	Total	7533.708	15			

T-Test

Group Statistics					
Size		N	Mean	Std. Deviation	Std. Error Mean
N	Small size	8	71.8475	8.03702	2.84151
	Large size	8	50.5938	16.27165	5.75290
P	Small size	8	50.4338	29.61017	10.46878
	Large size	8	65.1775	8.67558	3.06728

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
N	Equal variances assumed	5.723	.031	3.312	14	.005	21.25375	6.41639	7.49197	35.01553
	Equal variances not assumed			3.312	10.224	.008	21.25375	6.41639	6.99943	35.50807
P	Equal variances assumed	6.137	.027	-1.352	14	.198	-14.74375	10.90887	38.14095	8.65345
	Equal variances not assumed			-1.352	8.193	.213	-14.74375	10.90887	39.79686	10.30936



Effect of moving rate Burned blood cockle shell**Descriptives**

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
N	300	8	71.8475	8.03702	2.84151	65.1284	78.5666	62.22	86.66
	600	8	58.7925	8.67574	3.06734	51.5394	66.0456	46.66	68.89
	900	8	40.2288	8.56007	3.02644	33.0724	47.3851	29.87	51.73
	1200	8	35.7138	8.17436	2.89007	28.8798	42.5477	21.43	46.43
	Total	32	51.6456	16.75883	2.96257	45.6034	57.6878	21.43	86.66
P	300	8	50.4338	29.61017	10.46878	25.6790	75.1885	1.81	87.63
	600	8	67.1250	26.49869	9.36870	44.9715	89.2785	1.83	80.00
	900	8	62.2150	23.89757	8.44907	42.2361	82.1939	8.49	79.09
	1200	8	51.3738	16.93278	5.98664	37.2176	65.5299	21.96	77.65
	Total	32	57.7869	24.54314	4.33865	48.9381	66.6356	1.81	87.63

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
N	Between Groups	6746.906	3	2248.969	32.133	.000
	Within Groups	1959.699	28	69.989		
	Total	8706.605	31			
P	Between Groups	1616.044	3	538.681	.884	.461
	Within Groups	17057.290	28	609.189		
	Total	18673.334	31			

Multiple Comparisons

LSD

Dependent Variable	(I) water	(J) water	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
N	300	600	13.05500(*)	4.18298	.004	4.4866	21.6234
		900	31.61875(*)	4.18298	.000	23.0503	40.1872
		1200	36.13375(*)	4.18298	.000	27.5653	44.7022
	600	300	-13.05500(*)	4.18298	.004	-21.6234	-4.4866
		900	18.56375(*)	4.18298	.000	9.9953	27.1322
		1200	23.07875(*)	4.18298	.000	14.5103	31.6472
	900	300	-31.61875(*)	4.18298	.000	-40.1872	-23.0503
		600	-18.56375(*)	4.18298	.000	-27.1322	-9.9953
		1200	4.51500	4.18298	.290	-4.0534	13.0834
	1200	300	-36.13375(*)	4.18298	.000	-44.7022	-27.5653
		600	-23.07875(*)	4.18298	.000	-31.6472	-14.5103
		900	-4.51500	4.18298	.290	-13.0834	4.0534
P	300	600	-16.69125	12.34088	.187	-41.9704	8.5879
		900	-11.78125	12.34088	.348	-37.0604	13.4979
		1200	-.94000	12.34088	.940	-26.2191	24.3391
	600	300	16.69125	12.34088	.187	-8.5879	41.9704
		900	4.91000	12.34088	.694	-20.3691	30.1891
		1200	15.75125	12.34088	.212	-9.5279	41.0304
	900	300	11.78125	12.34088	.348	-13.4979	37.0604
		600	-4.91000	12.34088	.694	-30.1891	20.3691
		1200	10.84125	12.34088	.387	-14.4379	36.1204
	1200	300	.94000	12.34088	.940	-24.3391	26.2191
		600	-15.75125	12.34088	.212	-41.0304	9.5279
		900	-10.84125	12.34088	.387	-36.1204	14.4379

* The mean difference is significant at the .05 level.

Effect of Type blood cockle shell

Descriptives

						95% Confidence Interval for Mean			
						Lower Bound	Upper Bound		
N		N	Mean	Std. Deviation	Std. Error			Minimum	Maximum
N	burned	8	71.8475	8.03702	2.84151	65.1284	78.5666	62.22	86.66
	fresh	8	22.5613	10.24636	3.62264	13.9951	31.1274	4.88	31.71
	Total	16	47.2044	26.96122	6.74030	32.8378	61.5710	4.88	86.66
P	burned	8	50.4338	29.61017	10.46878	25.6790	75.1885	1.81	87.63
	fresh	8	42.9688	7.31491	2.58621	36.8533	49.0842	33.83	57.70
	Total	16	46.7013	21.18930	5.29732	35.4103	57.9922	1.81	87.63

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
N	Between Groups	9716.538	1	9716.538	114.594	.000
	Within Groups	1187.071	14	84.791		
	Total	10903.609	15			
P	Between Groups	222.905	1	222.905	.479	.500
	Within Groups	6511.891	14	465.135		
	Total	6734.796	15			

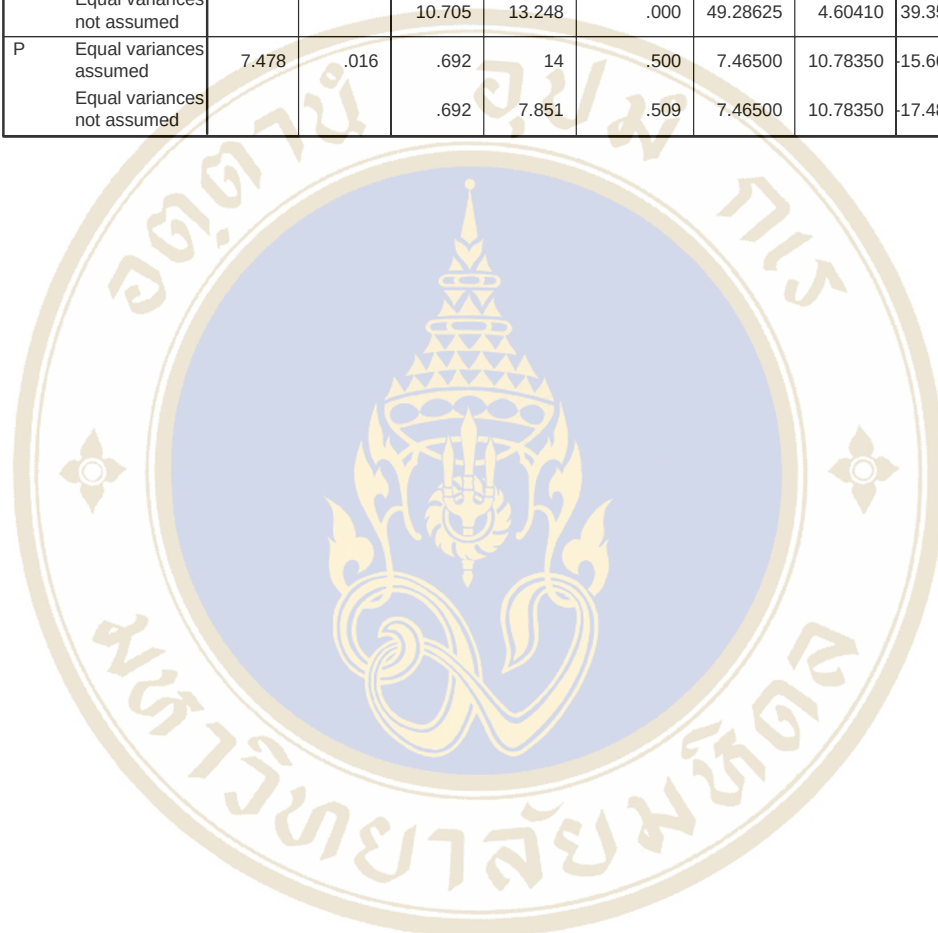
T-Test

Group Statistics

		N	Mean	Std. Deviation	Std. Error Mean
N	burned	8	71.8475	8.03702	2.84151
	fresh	8	22.5613	10.24636	3.62264
P	burned	8	50.4338	29.61017	10.46878
	fresh	8	42.9688	7.31491	2.58621

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
N	Equal variances assumed	1.082	.316	10.705	14	.000	49.28625	4.60410	39.41145	59.16105
	Equal variances not assumed			10.705	13.248	.000	49.28625	4.60410	39.35862	59.21388
P	Equal variances assumed	7.478	.016	.692	14	.500	7.46500	10.78350	15.66330	30.59330
	Equal variances not assumed			.692	7.851	.509	7.46500	10.78350	17.48404	32.41404



APPENDIX C

Table C-1 Total nitrogen adsorption isotherm results of burned blood cockle shells

Conc. (mg N/L)	Dose of burned blood cockle (kg.) m	Final Conc. (mg/L) C	Solute Adsorbed (mg) x	Adsorption capacity (mg/g) Q, x/m	c/q	Log c	Log x/m
1	2.7	0.84	0.16	0.0593	14.165	-0.0757	-1.2269
	2.7	0.56	0.44	0.1629	3.438	-0.2518	-0.7881
	2.7	0.28	0.72	0.2667	1.05	-0.5528	-0.5739
	2.7	0.28	0.72	0.2667	1.05	-0.5528	-0.5739
	2.7	0.28	0.72	0.2667	1.05	-0.5528	-0.5739
	2.7	0.36	0.64	0.237	1.519	-0.4437	-0.6253
	2.7	0.48	0.52	0.1926	2.492	-0.3188	-0.7153
	2.7	0.56	0.44	0.1629	3.438	-0.2518	-0.7881
5	2.7	0.84	0.16	0.0593	14.165	-0.0757	-1.2269
	2.7	4.2	0.8	0.2963	14.175	0.6232	-0.5283
	2.7	3.64	1.36	0.5037	7.227	0.5611	-0.2978
	2.7	3.08	1.92	0.7111	4.331	0.4886	-0.1481
	2.7	2.52	2.48	0.9185	2.744	0.4014	-0.0369
	2.7	2.24	2.76	1.0222	2.191	0.3502	0.0095
	2.7	2.36	2.64	0.9778	2.414	0.3729	-0.0097
	2.7	2.52	2.48	0.9185	2.744	0.4014	-0.0369
	2.7	2.78	2.22	0.8222	3.381	0.4440	-0.0850
10	2.7	7.84	2.16	0.8	9.8	0.8943	-0.0969
	2.7	7.56	2.44	0.9037	8.366	0.8785	-0.0439
	2.7	7	3	1.1111	6.301	0.8451	0.0458
	2.7	6.72	3.28	1.2148	5.532	0.8274	0.0845
	2.7	5.32	4.68	1.7333	3.069	0.7259	0.2389
	2.7	6.44	3.56	1.3185	4.884	0.8089	0.1201
	2.7	6.72	3.28	1.2148	5.532	0.8274	0.0845
	2.7	7	3	1.1111	6.301	0.8451	0.0458

Table C-1 Total nitrogen adsorption isotherm results of burned blood cockle shells (continued)

Conc. (mg N/L)	Dose of burned blood cockle (kg.) m	Final Conc. (mg/L) C	Solute Adsorbed (mg) x	Adsorption capacity (mg/g) Q, x/m	c/q	Log c	Log x/m
15	2.7	10.08	4.92	1.8222	5.532	1.0035	0.2606
	2.7	9.8	5.2	1.9259	5.089	0.9912	0.2846
	2.7	9.24	5.76	2.1333	4.331	0.9657	0.3291
	2.7	8.12	6.88	2.5481	3.187	0.9096	0.4062
	2.7	8.96	6.04	2.237	4.005	0.9523	0.3497
	2.7	9.24	5.76	2.1333	4.331	0.9657	0.3291
	2.7	9.24	5.76	2.1333	4.331	0.9657	0.3291
	2.7	10.08	4.92	1.8222	5.532	1.0037	0.2606

Table C-2 Phosphorus adsorption isotherm results of burned blood cockle shells

Conc. (mg N/L)	Dose of burned blood cockle (kg.) m	Final Conc. (mg/L) C	Solute Adsorbed (mg) x	Adsorption capacity (mg/g) Q, x/m	c/q	Log c	Log x/m
1	2.7	0.91	0.09	0.033	27.575	0.04096	-1.4815
	2.7	0.9	0.1	0.037	24.324	-0.0458	-1.4318
	2.7	0.86	0.14	0.052	16.539	-0.0655	-1.2839
	2.7	0.16	0.84	0.311	0.515	-0.7959	-0.5072
	2.7	0.12	0.88	0.3259	0.368	-0.9208	-0.4869
	2.7	0.12	0.88	0.3259	0.368	-0.9208	-0.4869
	2.7	0.12	0.88	0.3259	0.368	-0.9208	-0.4869
	2.7	0.14	0.86	0.3185	0.439	-0.8539	-0.4969
5	2.7	0.14	4.86	1.8	0.078	-0.8539	0.2553
	2.7	0.12	4.88	1.8074	0.066	-0.9208	0.2571
	2.7	0.12	4.88	1.8074	0.066	-0.9208	0.2571
	2.7	0.12	4.88	1.8074	0.066	-0.9208	0.2571
	2.7	0.11	4.89	1.8111	0.061	-0.9586	0.2579
	2.7	0.12	4.88	1.8074	0.066	-0.9208	0.2571
	2.7	0.12	4.88	1.8074	0.066	-0.9208	0.2571
	2.7	0.13	4.87	1.8037	0.072	-0.8861	0.2562
	2.7	0.14	4.86	1.8	0.078	-0.8539	0.2553
10	2.7	0.34	9.66	3.578	0.095	-0.4685	0.5536
	2.7	0.32	9.68	3.585	0.089	-0.4949	0.5545
	2.7	0.16	9.84	3.644	0.044	-0.7959	0.5616
	2.7	0.13	9.87	3.656	0.036	-0.8861	0.5630
	2.7	0.11	9.89	3.663	0.030	-0.9586	0.5638
	2.7	0.11	9.89	3.663	0.030	-0.9586	0.5638
	2.7	0.12	9.88	3.659	0.033	-0.9208	0.5634
	2.7	0.13	9.87	3.656	0.036	-0.8861	0.5630

Table C-2 Phosphorus adsorption isotherm results of burned blood cockle shells (continued)

Conc. (mg N/L)	Dose of burned blood cockle (kg.) m	Final Conc. (mg/L) C	Solute Adsorbed (mg) x	Adsorption capacity (mg/g) Q, x/m	c/q	Log c	Log x/m
15	2.7	1.15	13.85	5.1296	0.224	0.0607	0.7101
	2.7	1.14	13.86	5.0667	0.225	0.0569	0.7047
	2.7	0.58	14.42	5.3407	0.109	-0.2366	0.7276
	2.7	0.48	14.52	5.3778	0.089	-0.3188	0.7306
	2.7	0.12	14.88	5.5111	0.022	-0.9208	0.7412
	2.7	0.17	14.83	5.4926	0.031	-0.7696	0.7398
	2.7	0.18	14.82	5.4889	0.033	-0.7447	0.7395
	2.7	0.24	14.76	5.4667	0.044	-0.6198	0.7377

BIOGRAPHY

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