POLITEKNIK MELAKA

REMOVAL OF PHOSPHATE FROM AQUEOUS SOLUTION BY USING CALCINED WASTED HARD CLAM SHELL AS AN ADSORBENT

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(11DKA22F1052)

CIVIL ENGINEERING DEPARTMENT

SESSION I: 2024/2025

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ACKNOWLEDGMENT OF AUTHENTICITY AND OWNERSHIP

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1. I**, MUHAMMAD ADAM AIMAN BIN YUSWARDI (NO IC: 0[redacted])**, am a final-year student of the Civil Engineering Diploma, Department of Civil Engineering, Polytechnic of Malacca, located at No.2, Road PPM 10, Plaza Pandan Malim, 75250 Malacca.

2. I acknowledge that the "Projects above" and the intellectual property contained therein result from our original works/designs without taking or replicating any intel property from other parties.

3. We agree to relinquish the intellectual property of the "Project" to the "Polytechnic" to meet the requirements for the award of a Civil engineering diploma to us.

Made and truly acknowledged,

By that,

(**MUHAMMAD ADAM AIMAN BIN YUSWARDI**) .....

[redacted] (MUHAMMAD ADAM AIMAN BIN YUSWARDI)

In front of me, **NORZAINARIAH BINTI ABU HASSAN** ([redacted])

…….....……..... as project supervisor on date 14/2/2024

(NORZAINARIAH BINTI ABU HASSAN)

APPRECIATION

First and foremost, I would like to express my heartfelt gratitude to Allah SWT for granting me the strength, patience, and perseverance to complete this final-year project.

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Lastly, I would like to thank all my lecturers, friends, and everyone who contributed to this project in any way. Your support and kindness will never be forgotten.

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ABSTRACT

Phosphorus pollution poses a serious environmental problem that causes water eutrophication, disturbing the aquatic ecosystem and seriously degrading the quality of water. This research work is based on calcined hard clam shell (CHCS) utilization as an environment-friendly and sustainable adsorbent for the aforementioned problem. Emphasis was given to assess the CHCS performance in removing phosphorus and to understand the process of adsorption with the help of isotherm models. The batch experiments showed that the CHCS was able to completely remove 100% of phosphorus at all different conditions. The adsorption behaviour was analyzed by a Freundlich and Langmuir model; among them, the Freundlich model seemed to fit better because it can describe adsorption on a heterogeneous surface, with R^2 as high as 0.3163. These findings indicate that calcined hard clam shells show much promise as an inexpensive and green solution for the elimination of phosphorus in wastewater treatment. The use of this approach serves to decrease water pollution and involves waste material recycling, which has beneficial environmental implications.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

N	Nitrogen
P	Phosphorus
DO	Dissolved oxygen
Chl-a	Chlorophyll-a
$CaCO_3$	Calcium carbonate
DOE	Department of Environment
NWQS	National Water Quality Standards
HABs	Harmful algal blooms
CHCS	Calcined hard clam shells
q_e	Adsorption capacity
E%	Removal efficiency
C_e	Concentration of the adsorbate

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The most crucial resource for an organism's life support system is water. Water is a basic and essential necessity for all living things on Earth, including humans. As a result, water that humans drink needs to be safe, readily available, sufficient, and uncontaminated. Both the aquatic ecosystem and human health are seriously threatened by pollutants in water bodies. Numerous contaminants found in water have been divided into various categories, such as microbiological, inorganic, organic, thermal, and radioactive pollutants (Madhav et al., 2020).

Water eutrophication is becoming a more significant issue. A relatively closed, slow-moving body of water (such as a lake, reservoir, river, or freshwater wetland) can become eutrophic due to an excess of nitrogen (N), phosphorus (P), and other inorganic nutrients. This process encourages the growth of algae and other plankton in the water, which lowers dissolved oxygen (DO), increases chlorophyll-a (Chl-a) content, and degrades the quality of the water. Fish and other aquatic creatures may perish because of this (Zhang et al., 2021).

Even though phosphorus is a necessary element for agricultural productivity, the supply of phosphorus substances is limited and cannot be replenished. Furthermore, pollution like water eutrophication is caused by the release of phosphate from wastewater treatment facilities and ineffective crop fertilisation. Thus, phosphorus recovery from wastewater represents a viable alternative source of phosphorus for agriculture (Luo et al., 2023).

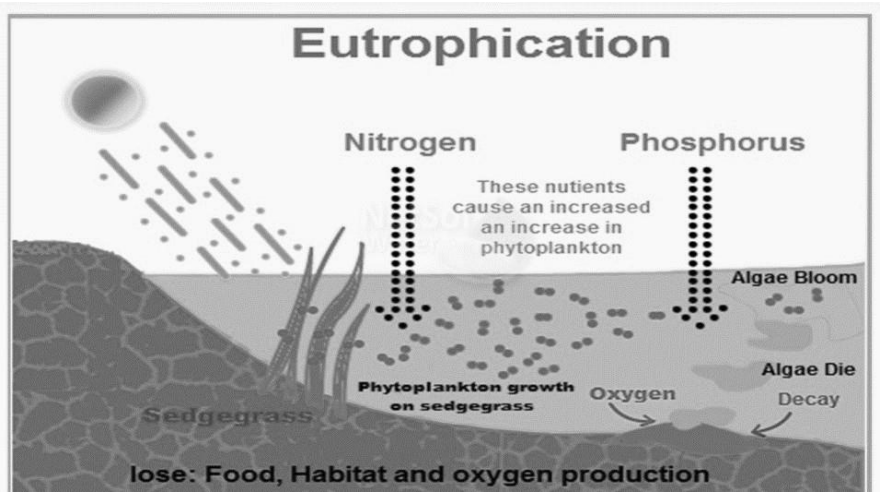

Figure 1: Eutrophication process

The hard clam, scientifically known as ***Mercenaria mercenaria***. As its name implies, the clam's tough shell protects its fragile body from harm. Calcium carbonate ($CaCO_3$), mostly in the form of calcite, makes up most of the hard clamshell. The hard structure of the shell is formed by this combination. When clams are harvested for their meat, large amounts of shell are discarded as waste. How to handle these wastes, which are typically landfilled, has been a major issue. Research is being done on using these shells as a recycling resource to remove phosphate from aqueous solutions.

1.2 BACKGROUND OF STUDY

Water pollution has become one of the world's most severe environmental issues, caused mostly by industrial development, agricultural growth, and population. Contamination of water bodies presents serious health concerns to humans, destroys biodiversity, and disrupts ecosystems. Pollutants can be chemical, physical, or biological factors that affect water quality, making them dangerous for human consumption and harmful to aquatic life. Heavy metals like lead, mercury, and cadmium, organic pollutants like industrial chemicals and pesticides, and nutrients like phosphorus and nitrogen that hasten eutrophication are examples of major pollutants. The problem has been made worse by untreated sewage, plastics, and microplastics, which impact freshwater and marine environments.

Phosphorus is one of the many chemicals that has come to light as a major cause of water pollution, especially in freshwater systems. As a naturally occurring element necessary for all living things, phosphorus is important for agricultural productivity because it is a component of fertilisers. However, the overuse of fertilisers containing phosphorus and its leakage into waterways have created serious environmental problems. The overgrowth of algae is triggered by excess phosphorus entering aquatic ecosystems; this process is called eutrophication. Eutrophication reduces oxygen levels in water, resulting in the death of aquatic species, fish kills, and overall worsening water quality.

Phosphorus contamination has been recognized as a major global impact on the decline of water quality in numerous areas. Lake Erie in North America is one of the most famous examples of phosphorus-induced water pollution. Because of high nutrient loading from agricultural runoff, the lake frequently experiences harmful algal blooms. Numerous large-scale algal blooms have occurred in the lake in recent decades, creating poisonous water conditions that forced surrounding towns to cut off their water sources. Asia's Yangtze River in China is contaminated with phosphorus due to agricultural practices and industrial effluents, lowering the water quality and endangering human health and biodiversity.

Like many other countries, Malaysia is struggling with the problem of water contamination, especially from phosphorus. The nation's water bodies are now carrying more nutrients due to the quick industrialisation and growth of the agriculture industry. Rice paddies, rubber estates, and palm oil plantations are the main sources of phosphorus contamination. High quantities of phosphorus have been found in the Langat and Klang rivers, causing severe eutrophication and frequent algal blooms. For millions of Malaysians, these rivers are essential sources of water, therefore pollution from them poses a serious risk to public health.

Malaysian water quality management is regulated by several laws and policies, most notably the Department of Environment's (DOE) National Water Quality Standards (NWQS). Water bodies are divided into five categories by these standards, from Category I (extremely clean water suitable for protection of natural habitats) to Category V (heavily polluted water requiring considerable treatment before use). The classification is based on the designated uses of the water bodies. Because phosphorus contributes to eutrophication, its quantities are routinely monitored as part of the NWQS. To protect human health and the environment, the NWQS establishes strict nutrient levels, including phosphorus, for bodies of water intended for residential use, water supply, or tourism.

The removal of phosphorus from water has been studied previously using a variety of methods, including the use of chemicals, biological treatments, and adsorption procedures. In particular, adsorption has drawn a lot of interest because of its ease of use, affordability, and capacity for using natural materials. Numerous research has looked into the ability of various adsorbents, such as natural minerals, industrial byproducts, and agricultural waste, to extract phosphorus from aqueous solutions. Calcium-based materials are very effective in phosphorus adsorption due to their capacity to form stable complexes with phosphate ions.

1.3 PROBLEM STATEMENT

Phosphorus growth in natural water bodies has become a serious environmental problem that has a substantial impact on aquatic ecosystems and water quality. The main cause of eutrophication is excessive phosphorus loading, which has some negative consequences such as oxygen depletion, harmful algal blooms (HABs), and a decline in biodiversity. These circumstances can make bodies of water dangerous for economic and food product usage, endangering human health in addition to harming aquatic species. Even though phosphorus is known to be a major cause of water pollution, conventional methods of removal, such as chemical precipitation and biological treatment, frequently fall short, are costly, or have negative environmental effects. Thus, there is a pressing need for phosphorus removal techniques that are efficient, economical, and sustainable.

The problem is particularly concerning in Malaysia, where phosphorus contamination in rivers and lakes is mostly caused by industrial discharges, urban runoff, and agricultural practices. Major water bodies, such as the Klang and Langat Rivers, have shown high phosphorus levels, which harms the water quality and local people who depend on these resources for agriculture and drinking water. The detrimental effects of phosphorus pollution are amplified in places such as Tasik Chini, where habitat degradation and a fall in biodiversity are the outcomes of eutrophication. The Malaysian government's current water quality guidelines attempt to address these issues, but compliance is still a major barrier, especially in areas where increased agricultural production and rapid growth have increased fertiliser runoff.

While some research has looked into different adsorbents for the removal of phosphorus, little research has been done on the possibility of employing waste-derived materials, particularly calcined hard clam shells. Reusing hard clam shells, which are an easily accessible material but are frequently thrown away as garbage, offers a chance to support sustainable practices. However, the effectiveness of calcined clam shells in extracting phosphorus from aqueous solutions and the adsorption mechanisms are still mostly unproven. Prior studies have demonstrated the adsorption of phosphate ions by calcium-based materials. However, there is a deficiency of thorough research on the adsorption capacity and behaviour of calcined hard clam shells.

1.4 RESEARCH OBJECTIVE

The objectives of the study are the list:

1. To produce an adsorbent from hard clam shells.
2. To determine the removal efficiency and adsorption capacity.
3. To verify the isotherm adsorption model for phosphorus adsorption onto calcined hard clam shells, based on data obtained from batch experiments.

1.5 IMPORTANCE OF RESEARCH

By utilising materials obtained from waste, this study offers a sustainable method for phosphorus removal that solves both industrial and environmental issues. Seaside places have numerous amounts of hard clam shells, which are frequently thrown away as waste yet can be a reasonably priced resource. In addition to solving the phosphorus removal problem, using them as an adsorbent encourages waste reduction and circular economy principles. By testing the isotherm adsorption model, this study will provide significant insight into the adsorption mechanism, allowing for future optimization and application of this approach for commercial applications. The outcomes may greatly aid in the management of water quality, especially in areas where eutrophication is an issue, and encourage the use of green technology in wastewater treatment facilities.

1.6 SCOPE OF THE STUDY

The scope of this research is defined by several key limitations. To begin with, hard clam shells will be the main raw material used in this study. They will be gathered from Kuala Selangor, Malaysia's coastal area. These shells will be calcined to provide the adsorbent needed to remove phosphorus. For the purpose is to determining the calcined clam shells' adsorptive capacity, the investigation will only utilize an aqueous solution as the water sample, filled with known phosphorus amounts. This study only looks at the chemical parameter (P), with a clear objective of eliminating phosphate ions from the water. Other pollutants like nitrogen, heavy metals, or organic substances are not examined. The calcination procedure and batch adsorption tests, among other laboratory tests, will be carried out at Makmal Teknologi Air Sisa, Universiti Tun Hussein Onn Malaysia (UTHM). The UTHM controlled laboratory environment will supply the infrastructure required to guarantee the accuracy and consistency of the phosphorus adsorption testing.

1.7 SUMMARY

The research on using calcined hard clam shells as an adsorbent to remove phosphorus from water bodies—a major environmental concern—was presented in this chapter. The background made clear how important it is to find alternate, affordable methods of removing phosphorus. The difficulty of eutrophication and the limitations of current removal techniques were described in the problem statement. While the production and testing of calcined clam shells were the main goals of the study, its potential environmental benefits and contribution to sustainable practices were also highlighted. The study's bounds were established by the scope, which concentrated on isotherm model verification and laboratory-scale experiments. The goal of this study is to offer a cutting-edge, reasonably priced remedy for phosphorus pollution in water.