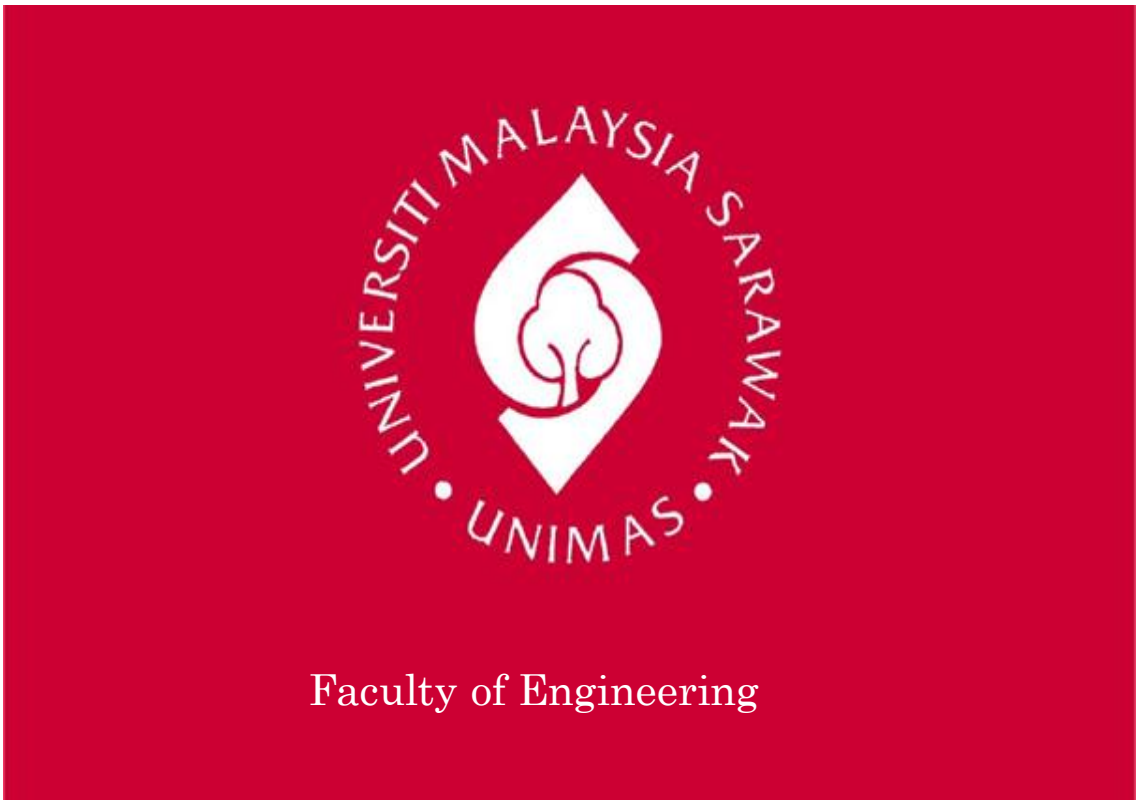

CORRELATION BETWEEN RAW WATER QUALITY AND ALGAL BLOOM IN COMMUNITY WATER TREATMENT SYSTEM

MUHAMMAD IMAN BIN MUHAMMAD IZZAM

Bachelor of Engineering (Chemical Engineering)

With Honours

2022

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

Please tick (√)	
Final Year Project Report	√
Masters	
PhD	

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This declaration is made on the **27TH** day of JUNE 2022

Student's Declaration:

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This final year project thesis entitled **"Correlation Between Raw Water Quality and Algal Bloom in Community Wastewater Treatment System "** was prepared by Muhammad Iman Bin Muhammad Izzam (64946) as Final Year Project course fulfilment for the Bachelor of Engineering with Honours (Chemical Engineering) is hereby read and approved by:

27TH JANUARY 2022

_____ _____

NORAZIAH ABDUL WAHAB Date

(Final Year Project Supervisor)

CORRELATION BETWEEN RAW WATER QUALITY AND ALGAL BLOOM IN COMMUNITY WATER TREATMENT SYSTEM

MUHAMMAD IMAN BIN MUHAMMAD IZZAM

A thesis is submitted in partial fulfilment
of requirement for the degree of
Bachelor of Engineering with Honours
(Chemical Engineering)

Faculty of Engineering
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2022

Dedicated to my supportive supervisor my beloved parents, family, and friends, who always supported and encourage me upon completing this thesis.

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ABSTRACT

Approach to fresh drinking water is a basic requirement for human being survival. Moreover 70% of the Earth's surface is covered by water, with 97.5% of it being saltwater and only 2.5% being fresh water. Freshwater consumption has grown dramatically in recent years as a result of population and economic growth. Surface water provides 98 percent of Malaysia's fresh water thus, an appropriate wastewater treatment is necessary to assure a constant supply of clean water. Algal blooms are common in wastewater treatment systems, posing a threat to the clean water delivered to customers. Some key constraints on algae cultivation, productivity, and harvesting from wastewater treatment. Light intensity and exposure, food levels, nitrogen, phosphorus, water temperature and stratification, and the synthesis of allelochemicals by competing organisms are all factors that impact cyanotoxin production. As a result, an alternate approach that is more feasibly affordable and efficient must be discovered in order to solve this problem. The primary objective for this research study is to determine which water quality characteristics have most impact on the formation of algal blooms. Factors which contributing the development of algal bloom, the optimum parameters which lead to the maximum number of algae will be studied in depth. Three parameters have been estimated as the key factors on the development in which algae growth was studied by measure the final and initial mass of algal biomass. Analytical method is conducted to correlate between water quality and algal bloom. At the end of the study, the condition on the algal bloom occurring was at temperature of 32ºC, high amount of nutrients and at acidic condition of pH 5.0. The determination of the condition of algal bloom occurring lead to the proposed method on the prevention the algal bloom. Temperature and pH controller were being proposed to be used as to monitor and regulate the condition in the water treatment system to avoid the surrounding that not favoured to the growth. Amount of nutrients can be monitored by regularly checked by analysis method.

Keywords: *Wastewater Treatment; Algal Bloom; Water Quality; Temperature; pH; Nutrients*

ABSTRAK

Pendekatan kepada air minuman segar adalah keperluan asas untuk kelangsungan hidup manusia. Lebih-lebih lagi 70% daripada permukaan Bumi diliputi oleh air, dengan 97.5% daripadanya adalah air masin dan hanya 2.5% adalah air tawar. Penggunaan air tawar telah berkembang secara mendadak dalam beberapa tahun kebelakangan ini hasil daripada pertumbuhan penduduk dan ekonomi. Air permukaan membekalkan 98 peratus air tawar Malaysia oleh itu, rawatan air sisa yang sesuai adalah perlu untuk memastikan bekalan air bersih yang berterusan. Bunga alga adalah perkara biasa dalam sistem rawatan air sisa, yang menimbulkan ancaman kepada air bersih yang dihantar kepada pelanggan. Beberapa kekangan utama pada penanaman alga, produktiviti, dan penuaian daripada rawatan air sisa. Keamatan cahaya dan pendedahan, tahap makanan, nitrogen, fosforus, suhu air dan stratifikasi, dan sintesis alelokimia oleh organisma bersaing adalah semua faktor yang memberi kesan kepada pengeluaran sianotoksin. Akibatnya, pendekatan alternatif yang lebih berpatutan dan cekap mesti dicari untuk menyelesaikan masalah ini. Objektif utama untuk kajian penyelidikan ini adalah untuk menentukan ciri kualiti air yang paling memberi kesan kepada pembentukan bunga alga. Faktor-faktor yang menyumbang kepada perkembangan alga mekar, parameter optimum yang membawa kepada bilangan maksimum alga akan dikaji secara mendalam. Tiga parameter telah dianggarkan sebagai faktor utama dalam pembangunan di mana pertumbuhan alga dikaji dengan mengukur jisim akhir dan awal biojisim alga. Kaedah analisis dijalankan untuk mengaitkan antara kualiti air dan mekar alga. Pada akhir kajian, keadaan pada alga bloom yang berlaku adalah pada suhu 32ºC, jumlah nutrien yang tinggi dan pada keadaan berasid pH 5.0. Penentuan keadaan pembungaan alga yang berlaku membawa kepada kaedah yang dicadangkan untuk mencegah pembungaan alga. Pengawal suhu dan pH dicadangkan untuk digunakan sebagai memantau dan mengawal keadaan dalam sistem rawatan air untuk mengelakkan persekitaran yang tidak sesuai dengan pertumbuhan. Jumlah nutrien boleh dipantau dengan kerap diperiksa dengan kaedah analisis

***Kata kunci**: Rawatan air kumbahan; Algal Bloom; Kualiti air; Suhu; pH; nutrisi*

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

COD	-	Chemical oxygen demand
APEC	-	Asia-Pacific Economic Cooperation
TTN	-	Threshold taste number
TON	-	Threshold odour number
TDS	-	Total dissolved solids
EC	-	Electrical conductivity
DNA	-	Deoxyribonucleic acid
DO	-	Dissolved oxygen
BOD	-	Biochemical oxygen demand
SDI	-	Species diversity index
DI	-	Deionized water
TN	-	Total nitrogen
TP	-	Total phosphorus

CHAPTER 1

INTRODUCTION

1.1 Water as A Source of Life

Access to water and sanitation is a basic requirement for human survival**.** According to National Geographic (2014), water covers more than 70% of the Earth's surface, with 97.5% of that being saltwater and only 2.5% being fresh water. This implies that the rivalry for a clean, plentiful supply of water for drinking, cooking, bathing, and supporting life becomes more intense every year.

Rivers are the most often used raw water sources in Malaysia. There are 180 rivers in all, with 150 of them being important river systems, and these rivers and streams provide 97% of Malaysia's water supply (Kalithasan, 2013). According to The Department of Environmental, in the Environment Quality Report (2009), in comparison to prior years, 46% of Malaysia's entire rivers have become contaminated. According to Kozaki et al (2016), 42 Malaysian tributaries were designated as very contaminated in the late 1980s. Anticipated to water quality degradation caused by wastewater from the housing, industrial, and business/servicing sectors, about 60% of the main rivers were controlled for household, agricultural, and industrial reasons in the 1990s and 2000s. If pollution persists, access to safe drinking water will become more difficult. Despite the roles of fresh water crucial for public health, it is also playing an important role in ecological habitat provision.

1.2 Overview of Wastewater Treatment System

Wastewater treatment is the process of removing impurities from wastewater and converting it into effluent that may be recycled back into the water cycle. Prior to redistribution for agricultural uses or release into catchments, wastewater treatment plants are meant to eliminate chemical and biological pollutants in wastewater to safe and acceptable levels. The effluent which containing low amount of impurities has a low environmental impact and will utilised for a variety of uses or known as water reclamation. Various types of wastewater are treated by wastewater treatment plants of the proper type. One of the treatment facilities which is known for domestic treatment plant is sewage treatment plant with the aim to discharge an

effluent with is suitable to the surrounding environment, especially a river. According to SAMCOTech (2016), the components of a wastewater treatment system are determined by the wastewater characterization in relation to the plan's regulatory requirements for discharge. Typical wastewater treatment facility process usually consists a step which are coagulation, flocculation, sedimentation, filtration, disinfection, and distribution.

Pollutants in wastewater are reduced to a level that nature can tolerate in treatment plants. Even nature has a capability of dealing with little quantities of water waste and pollution, but it would be overwhelmed if humans did not treat the billions of gallons of wastewater and sewage created every day before releasing it back into the ecosystem. Untreated water may provide a home for various diseases-causing organism such as E-coli to reproduce and resulting in various health problem which are diarrhea. Untreated water also may affect the ecosystem of marine life. According to Ariffin et al (2015), excessive of plant an algal growth due to eutrophication caused by enrichment of nutrients contributed to damaging of marine life ecosystem.

1.3 Wastewater Treatment System in Malaysia

According to the United Nations (2009), more than 80% of sewage in underdeveloped nations is released untreated, damaging rivers, lakes, and coastal regions as many of large cities in middle-income countries does not provided a water treatment plant due to sewage generation problem as increasing in population and economic growth. According to Asia-Pacific Economic Cooperation, APEC (2009), 27 million of Malaysian people produce six million tonnes of sewage which the sewage will be cleansed and discharged in to the rivers. Since water is the most crucial substance for people in Malaysia where water has been utilized to do everyday tasks, wastewater treatment plant has been designated to treat wastewater in providing clean water to living substance. In addition, post-utilization of clean water consumed by households, industries, and enterprises must be treated before being released back into the environment.

Due to population and economic expansion, freshwater demand has risen substantially in recent years. Since the surface water supplies 98% of Malaysia’s fresh water, a proper wastewater treatment is required to ensure that clean water supply is always adequate. According to Gude (2015), due to rising urbanization, the population linked to wastewater collection and treatment has expanded, and more stringent criteria for the purity of water effluents have been implemented. Excessive and indiscriminate discharge of wastewater even

from residences to drains and into rivers with limited or no treatment contaminates raw surface water. This deterioration in water quality limits the water's utility for everyday uses. The Department of Environment Malaysia has monitored 72% of the 473 rivers in 2013 were found polluted in which 25 rivers were classified as highly polluted (Ariffin et al, 2015). In Malaysia, there are 8,000 public wastewater treatment facilities, 500 network pumping stations, 17,000 kilometers of underground sewerage pipelines, and 500,000 residential septic tanks connected to the sewers (APEC, 2009). In order to cope a grow demand towards a better and more effective sanitation services as well as water quality, the government pushed private organizations to establish wastewater treatment systems.

1.4 Overview of Algal Bloom

Algae is a broad term that encompasses a wide range of aquatic photosynthetic organisms, including both macroscopic multicellular species like seaweed and microscopic unicellular organisms like cyanobacteria. According to Robert (2016), the accumulation of rapidly increases in population of algae in freshwater and marine water system is known as an algal bloom or called as algae bloom. Rather than macro algae, the terms algal bloom generally refers to the rapid proliferation of small unicellular algae. An algal bloom community can be detect based on the colouring in the water caused by the algae's pigments which it is a common indicator (Robert, 2016).

The presence of algal blooms can be closely linked when entire body of water become progressively enriched with a nutrient, such as nitrogen or phosphorus through a process known as eutrophication. As indicated by Schindler et al (2004), increasing in the concentrations of nutrients lead to the increment fecundity of aquatic plants. As eutrophication process continues, the degradation of biological activity of marine ecosystem will be decrease. Rich-nutrients from fertiliser runoff enters the aquatic system and causes excessive algae growth is one of the reasons of the formation of an algal bloom. An algal bloom has a wide-ranging impact on the ecology. The consequences range from nonthreatening feeding of higher trophic levels to more detrimental impacts such as obstructing sunlight from reaching other creatures, causing oxygen depletion in the water, and, depending on the organism, secreting poisons into the water. According to Carpenter (2005), nutrient overabundance in aquatic habitats, resulting in algal blooms and anoxic events is a serious problem that need to be cope as it is a widespread environmental problem. Whenever nutrients including phosphate and nitrate are added to

water, microalgae species proliferate quickly and prolifically, causing an undesired disturbance in the aquatic ecosystem's equilibrium. (Volterra et al. 2002).

1.5 Problem Statement

A sustainable water-treatment system provides effective water treatment at low costs while protecting the interests of people, the natural habitats, and the organization. To put it another way, it should provide long-term environmental, economic, and social advantages. Municipal wastewater, which contains high levels of nitrogen and phosphorus compounds, contributes significantly to the worsening of water trophic conditions. Furthermore, as a result of the development of water supply and wastewater disposal systems, the nutrient load originating from the city is constantly increasing in tandem with economic growth, population growth, urbanization expansion, and as a result of the development of water supply and wastewater disposal systems. According to Preisner et al., (2020), mitigation of eutrophication, exacerbated by excessive nutrient load discharge in wastewaters governed by stringent regulatory regulations, is one of the world's most pressing issues today. As a result, reducing the biogenic load supplied into wastewater receivers has become a critical approach for preventing eutrophication and limiting its negative repercussions.

An effective water treatment system that offers acceptable water quality should be monitored to ensure that algal bloom development does not occur in an uncontrollable manner. To guarantee that the growth of algal blooms is not accelerated, measures in resolving this issue must focus even more on the variables that cause the creation of algal blooms. Several national water quality monitoring systems include eutrophication-related criteria. Values of allowed basic wastewater quality parameters, which determine the allowable load are sometimes insufficient to comprehend the influence of treated wastewater on the development of eutrophication in wastewater receivers. Hence, this researched is carried out to investigate the prevention mechanism in order to minimize the formation of algal bloom by studying the relation of water quality and formation of algal bloom in community wastewater treatment system.

1.6 Research Objectives

The primary aim of this research is to study the correlation between raw water quality and algal bloom in community water treatment system by focusing on the investigation on how to control the algal bloom by investigated its factors. There are three research objectives that have been highlighted in this study. As a result, the objectives are as follows:

i. To identify and study the fouling water parameter that causes algal bloom in community water treatment system.
ii. To correlate the raw water quality and algal blooms; and
iii. To propose the mechanism to prevent algal blooms in community water treatment system.

1.7 Scope of Study

Through multivariate methods of statistical analysis, the relationship between algae and water quality indices are described and the main driving factors for eutrophication in community wastewater treatment systems has been identified through key component analysis. Through the identification of this method, a proposal on the limit factor for dominant algal growth depends location to deepen an understanding of water quality and reduction of both nitrogen and phosphorus is essential for long-term eutrophication control in this hyper-eutrophic system. The temperature of water is another significant control factor for the development of algal bloom. Using analysis of major components, nutrients pollution from anthropogenic and natural inputs identified as a major driving factor for water quality problems. Moreover, five principals' components have been extracted and characterized by high spatial variations in community wastewater treatment system. After water quality and algal bloom growth-driving factors have been studied and identified, the implementation of mechanisms in preventing algal bloom formation can be discussed and proposed further. Finally, the efficiency of the proposed method will be studied in ensuring minimizing the formation of algal blooms in community wastewater treatment system.

1.8 Research Gap

Algae bloom proliferation can still be found in wastewater treatment systems in some situations. Although certain aspects have been highlighted in guaranteeing water quality, such as the use of activated carbon in regulating water nutrients so that water nutrients are constantly in a state that is not conducive to algal development, others have been overlooked. Furthermore, wastewater treatment is carried out in a closed environment, away from sunshine, which is a key component in the development of algae. However, algal bloom still developed. This is due to the fact that some factors are overlooked. Some information such as the water quality parameters need to be investigated in which what fouling water parameter that contribute the most to the development of an algae before providing a solution on how to be preventing an algal bloom.

CHAPTER 2

LITERATURE REVIEW

2.1 Eutrophication

Excessive plant and algal growth are a symptom of eutrophication, which is caused by increased availability of one or more limiting growth sources for photosynthesis, such as sunlight, carbon dioxide, and nitrogen fertilizers (Schindler, 2006). As lakes age and silt fills in, eutrophication happens naturally over a long time. However, through both point-source discharges and non-point loadings of limiting nutrients, such as nitrogen and phosphorus, into aquatic ecosystems, human activities have accelerated the rate and extent of eutrophication, with dramatic consequences for drinking water sources, fisheries, and recreational water bodies. Nuisance an obvious result of eutrophication is algal blooms, which can cause considerable biological damage in water bodies and nearby streams. The water body may become oxygen-depleted as a result of the bacterial degradation of the algae.

2.2 Algal Bloom in Wastewater Treatment System

Wastewater treatment system use a three-part treatment process which consist of a primary treatment phase that removes solids, a secondary treatment phase that reduces organic material concentrations, and a tertiary treatment phase that eliminates harmful bacteria. To remove particle matter from influent sewage, first treatment uses mechanical clarifiers or gravity sedimentation (Gernaey et al., 2001). Wastewater treatment system employ activated sludge rather than the utilization of an algae for nutrient removal in the secondary phase of treatment. Aeration systems suspend flocculant-containing microorganisms in the activated sludge process. Aeration ensures a constant supply of oxygen and turbulence, creating the ideal condition for microbial interaction with all organic compounds floating in the water column, resulting in maximal organic compound breakdown. Membrane filtering and chemical disinfection are used in the tertiary phase to eliminate any leftover phosphates and bacteria. Concerning cyanobacterial blooms, wastewater treatment system is prone to them because to the extended water residence periods and nutrient-rich environment. The persistence of potentially harmful cyanobacterial species might stymie treatment and put end users' health at risk. According to Kwon et al., (2005), organic material trapped in cyanobacterial cells'