RHIZOFILTRATION PROCESS TO REMOVE ORGANIC AND HEAVY METALS IN KOTASAS LAKE

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ABSTRAK

Air tercemar kerana proses pencemar, juga dikenali sebagai kesan negatif penting oleh rintangan spesies sianobakteria terhadap pertumbuhan biojisim dalam sistem biologi air tawar. Rawatan in-situ tanah tercemar peringkat tinggi dengan fitoremediasi adalah pilihan yang berdaya maju. Fitoremediasi ialah teknik pengantaraan tumbuhan yang memerlukan penggunaan tumbuhan untuk menyerap dan menghapuskan bahan cemar unsur, atau untuk mengurangkan kepekatan atau bioavailabilitinya di dalam tanah. Tumbuhan boleh mengambil bahan dari tanah melalui sistem akarnya, walaupun pada kepekatan yang rendah. Fitostabilisasi, fitoekstraksi, fitovolatilisasi, dan fitofiltrasi adalah teknik fitoremediasi yang paling kerap digunakan dalam tanah dan air yang tercemar logam berat dan organik. Objektif penyelidikan ini adalah untuk meningkatkan kualiti air dan mengurangkan tahap pencemaran di Tasik KotaSAS dengan mengurai, menyerap dan memetabolismekannya menggunakan tumbuhan hijau hidup untuk mendapatkan semula sumber air dan tanah di situ. Ujian dan kajian akan dijalankan di lapangan untuk data in-situ dan di Makmal Alam Sekitar Universiti Malaysia Pahang dan Makmal Pusat untuk pengumpulan data ex-situ. Air kumbahan telah dikumpulkan di kawasan Tasik KotaSAS, dan ia dianalisis untuk mengumpul data kualiti air. Air tasik telah dikumpulkan dan dituangkan ke dalam beberapa bekas yang berbeza. Ia mempunyai 2 jenis tumbuhan yang telah digunakan iaitu *Lepironia Articulata* dan *Typha Angustifolia*. Semua bekas menggunakan jenis tumbuhan yang berbeza. Sebanyak 10 parameter disenaraikan di bawah: Permintaan Oksigen Biokimia (BOD), Permintaan Oksigen Kimia (COD), Oksigen Terlarut (DO), Jumlah Pepejal Terampai (TSS), pH, Suhu, Kekeruhan, Besi (Fe), Mangan (Mn), Nitrat (NO3) dan Aluminium (Al) untuk penilaian kualiti air. Akhirnya, terdapat perbezaan yang ketara antara tumbuhan sebelum dan selepas rawatan.

ABSTRACT

Polluted water because of the pollutant process, also known as essential negative impacts by cyanobacterial species resistance to the growth of biomass in a freshwater biological system. In-situ treatment of high-level contaminated soils with phytoremediation is a viable option. Phytoremediation is a plant-mediated technique that entails using plants to absorb and eliminate elemental contaminants, or to reduce their concentration or bioavailability in the soil. Plants could take substances from the soil through their root system, even at low concentrations. Phytostabilization, phytoextraction, phytovolatilization, and phytofiltration are the most often employed phytoremediation techniques in organic and heavy metal-polluted soil and water remediation. The objectives of this research were to enhance water quality and reduce pollution levels in the KotaSAS Lake by decomposing, absorbing, and metabolizing it using living green plants to recover water and soil resources in-situ. The tests and studies will take place in the field for in-situ data and in the University Malaysia Pahang Environmental Laboratory and Central Laboratory for ex-situ data collection. The wastewater was collected at KotaSAS Lake area, and it was analyzed to collect the water quality data. The lake water was collected and poured into few different containers. It has 2 type of plant that has been used which is *Lepironia Articulata* and *Typha Angustifolia*. All containers used the different type of plants. A total of 10 parameters listed below: Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), pH, Temperature, Turbidity, Iron (Fe), Manganese (Mn), Nitrate (NO3) and Aluminium (Al) as for water quality evaluation. Finally, there are considerable differences between the plants before and after treatment.

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LIST OF ABBREVIATIONS

IWQS	Interim Water Quality Standard
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
TSS	Total Suspended Solid
pH	Potential of Hydrogen
NH3	Ammonia Nitrogen
Fe	Iron
Mn	Manganese
A1	Aluminium
Mg/L	Milligram per Litter

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Water, air, and soil get polluted with high quantities of heavy metals, organic and inorganic contaminants because of urbanization and industrialization. Water pollution is defined as the discharge of pollutants into underground groundwater or lakes, streams, rivers, estuaries, and seas to the point that the contaminants interfere with beneficial water usage or the normal functioning of ecosystems. Bioaccumulation and biomagnification occur in the ecosystem, resulting in a variety of health problems such as colon cancer, heart disease, liver illness, and kidney failure. Removal, isolation, incineration, solidification, stabilization, vitrification, thermal treatment, solvent extraction, chemical oxidation, and other procedures are used to eliminate these pollutants.

Carbon, hydrogen, and perhaps other element-based compounds make up organic pollutants and wastes. Solvents, chemical compounds and intermediates, petroleum and gas molecules, and other liquid phase organic pollutants may contain volatile organic compounds (VOCs). Solid organic compounds include sludge, stationary bases, resins, chemicals, wax, paper, plastic, wood, edibles, and other solid organic compounds. Pesticides, herbicides, and fungicides are among the organic contaminants detected in stormwater runoff, all of which have been widely utilised in agricultural activities.

Heavy metals released into the environment in large quantities, such as by industrial wastes and fertilizers, cannot be biodegradable and accumulate at high levels, posing a significant threat to wildlife. Non-threshold toxins are heavy metals and metalloids like mercury (Hg), cadmium (Cd), lead (Pb), chromium (Cr), and arsenic (As), which may produce considerable biological toxicity even at extremely low concentrations (Rahman and Singh, 2019). Other heavy metals and metalloids, such as zinc (Zn), copper (Cu), nickel (Ni), iron (Fe), manganese (Mn), cobalt (Co), molybdenum (Mo), and antimony (Sb), have biological toxicity (Sb) (Ali et al., 2019). This metal enters the food chain through aquatic plants and animals if it is present in sediments. Certain heavy metals are required for healthy existence in small amounts, but excessive doses of any of them can cause acute or chronic toxicity (poisoning).

Heavy metals disrupt metabolic activity in two ways: they accumulate and disrupt function in vital organs and glands such the heart, brain, kidneys, bone, liver, and others. They displace vital nutritional ingredients from their original environment. Probably cannot see heavy metal poisoning all that often. These symptoms are significantly more likely to be caused by something else, such as a gut imbalance, hormone imbalance, thyroid problem, or even another type of environmental exposure, such as moulds toxins location, interfering with their biological function.

Water treatment methods are used, including primary (physical and physicochemical), secondary (biological), and tertiary (chemical). The combined treatment of industrial and municipal wastewaters can benefit both to the company and the municipality economically and ecologically. Water treatment refers to any technique that enhances the quality of water so that it may be used for a specified purpose. The final use might be drinking, industrial water supply, irrigation, river flow maintenance, water recreation, or any of a variety of other applications, including safely returning to the environment. Water treatment eliminates or decreases the concentration of pollutants and undesired components so that the water is suitable for its intended end-use.

1.2 Problem Statement

Monitoring the quality of a water body or reservoir has become a major priority in recent years as a means of determining the present state and long-term pattern for future management. Toxic heavy metals are released by urbanization and industrialization activities through sewage, runoff, and effluents, which account for most water pollution causes (Parveen et al., 2020). The lakes water quality is being harmed by the haphazard discharge from domestic wastes and effluent from residential areas. The region of soil and water have been contaminated as a result.

Plants are used in the phytoremediation process to clean up polluted media such as soil and water. Green plants are used to retain, sequester, or detoxify toxins from polluted soil and water, making phytoremediation a cost-effective and ecologically friendly process (Ashraf et al., 2019). Plants have efficient and complex methods to ingest micronutrients by creating chelating substances from their roots, which causes a pH shift in the soil and resulting in a redox reaction. Highly specialized methods are used to transport and store ingested nutrients. Similar processes are involved in the absorption, transport, and storage of harmful heavy metals, hence these uptake systems for micronutrients are the focus of interest for scientists in phytoremediation. Some heavy metals, such as Co, Cu, Fe, Mn, Mo, Ni, and Zn, are necessary for plant growth and development, whereas others, such as Pd, Cd, Hg, and As, are harmful to plants (Ozturk et al., 2021a).

Depending on the pollutant kinds, forms, and medium, various plants utilize different strategies (or combinations of approaches) to remediate soil and water. Phytodegradation, phytovolatilization, rhizofiltration, phytodegradation, and phytodegradation can all be used to treat contaminated ground water. Rhizofiltration, phytodegradation, and phytodegradation can be used to address surface and wastewater pollution. Contaminations in soil, sediments, and sludges are treated using phytoextraction, phytodegradation, phytostabilization, phytodegradation, and phytovolatilization. Hardy in nature, high biomass-producing, resistant to toxic effects of metals and pollutants, simple to cultivate, have high absorption capacity, and be non-attractive to herbivory are all desirable characteristics for phytoremediation plants and species.

The phytoremediation method also works by lowering pollutant toxicity, increasing pollutant availability, or encouraging plant growth. There is currently a lack of comprehensive knowledge on how to maximize the contribution of each phytoremediation mechanism through proper plant selection and techniques to improve the performance of phytoremediation technology. In a recent review study, it was also proposed that more information on the efficiency of phytoremediation and the elements that can help improve the Phyto processes be collected (Wei et al., 2021). Furthermore, recent studies on phytoremediation using new plant species, alternative management approaches, or new pollutants must be understood.

1.3 Objective of Study

The objective of this study:

1. To determine the parameter of water quality in KotaSAS Lake to comply with Interim Water Quality Standard (IWQS) of Malaysia.

2. To identify the effectiveness of green plant via phytoremediation process to remove pollutants in KotaSAS Lake water.

3. To evaluate the expansion and durability of aquatic plants in lake water for the purposes of phytoremediation.

1.4 Scope of Study

This research focuses on lake water from the KotaSAS Lake region that located in Kuantan, Pahang. KotaSAS Lake was selected as a research sample source for this project phytoremediation technique because it was the largest township developer, developing a fully integrated development with high-quality residential and commercial developments. Pollutants reach the lake because of growing residential areas and silage emissions from household waste, which raises pollution levels. As a result, KotaSAS Corporation must implement and manage preventative and corrective measures.

The tests and studies for this project will take place in the field for in-situ and ex-situ data. The ex-situ data as well as in the University Malaysia Pahang Environmental Laboratory and Central Laboratory. The two plant species used in this experiment were *Lepironia Articulata* and *Typha Angustifolia*. Water quality data will be acquired by collecting lake water and plants from the research area and analysing them. The Environmental lab will look at physicochemical factors, while the Central lab will look at organic and heavy metals waste. The wastewater quality and plant growth are being observed. In addition, several parameters such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), pH, Temperature, Turbidity, Iron (Fe), Nitrate (NO3), Manganese (Mn), and Aluminium (A1) are measured.

In addition, the exterior of the environmental laboratory will be used for lake water treatment by plants. To achieve the above-mentioned goals, the acquired and measured data will be examined. The project will compile a data of phytoremediation plants efficacy in removing organic and heavy metal contaminants from KotaSAS lake water. In addition, a lake water parameter was identified and compared with Interim Water Quality Standard (IWQS) of Malaysia to meet the objectives.

1.5 Significant of Study

Monitoring the quality of a water body or reservoir has been a major priority in recent years for determining present conditions and long-term patterns for future management. Excessive amounts of organic and heavy metals in our environment have become a severe concern to human and organisms' health, due to their long-term persistence in the environment. Physical procedures (soil washing and extraction, and heavy metal stability in the soil), chemical techniques (vitrify technology), chemical leaching or fixation, electrokinetic remediation, and biological approaches are some of the traditional ways used to restore heavy metal polluted sites (remediation using bacteria and fungi) (Dhaliwal et al., 2020). Natural endophytes (fungi and bacteria) are well-known for their ability to aid in the phytoremediation of contaminated soil and groundwater, as they provide plants with a variety of benefits, including increased nutrient uptake capacity (nitrogen fixation and phosphate solubilization), as well as stress tolerance.

Phytoremediation is a type of in-situ environmental decontamination that uses plant species to reduce the harmful effects of contaminants in water, soil, and air. Because it differs from physical chemical clean up procedures, his biotechnology has emerged as an alternate option for environmental decontamination. Vitrification (high temperatures), acid washing, and soil removal from the region are examples of such processes, all of which have greater related costs and have an impact on soil fertility and biodiversity (Yan et al., 2019). In the phytoremediation approach, specifically selected or engineered plants are frequently used in the remediation process.

There are several advantages to using phytoremediation, including cost effectiveness (phytoremediation is an autotrophic system powered by solar energy, making it easy to manage and maintain), risk reduction(by phytoremediation can be performed through contaminant removal, degradation, or containment, or a combination of these aspects), environmental and eco-friendly (it can reduce pollutant exposure to the environment and ecosystem), applicability (it can be applied over a large-scale field and easily disposed of), and it prevents erosion and metal leaching through a filtration system (Jacob et al., 2018).

Plants have natural characteristics that make them good candidates for cleaning polluted water and soil conditions. With its predilection for the ground, the root system comprises a massive surface area that allows plants to absorb and store water and nutrients required for development. Most plants also have extraordinary metabolic and absorption skills, as well as transport systems that can selectively take up numerous ions from water and soil and contribute favourably to their surroundings. Plants have a wide range of adaptations that allow them to deal with potentially dangerous quantities of metals and other toxins in the environment.

The focus of the invention was on rhizosphere bioremediation, also known as phytodegradation, which is the increased biodegradation of refractory organic pollutants by root-associated bacteria and fungus under the influence of specific plant species. From a rhizosphere impact, vegetation can enhance the overall quantity of beneficial fungi and bacteria in polluted water or soil. This research focuses on the current state of KotaSAS Lake pollution, including the lake water quality and toxins in the area soil, as well as wastewater treatment. The findings of this study will be utilised to establish a baseline for lake water quality and as references for future research. This research will also highlight how phytoremediation technology may be used to treat residential wastewater since it aids in the attainment of water quality parameters.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A lake is a body of water located in a basin, surrounded by land, and separated from any river or other outlet that feeds or drains it. Lakes are not oceans, yet they are part of the Earths water cycle, much like the much bigger seas. Lagoons, on the other hand, are often coastal areas of the ocean. Although there are no formal or scientific definitions, lakes are often larger and deeper than ponds, which are also located on land. Rivers and streams, on the other hand, normally run in a channel on land. Rivers and streams feed and drain most lakes. Due to increased flow from residential and agricultural sources, as well as urban growth, nutrient levels in many lakes and rivers have risen dramatically in the last 50 years.

When tiny or large volumes of materials (pollutants) are introduced into a body of water, it causes pollution. Increased input of wastewater owing to fast economic, industrial, and agricultural expansion has resulted in eutrophication of lakes, rivers, and seas, which has been exacerbated by the lack of sufficient water infrastructure and treatment facilities. Water pollution is a serious concern in developing nations, and appropriate water quality monitoring is necessary to understand and control water quality. It is necessary to utilise safe limits (standards) established by some authorities, such as the World Health Organization, when assessing the quality of water using water quality and stability indices (WHO). Water quality and appropriateness for certain uses such as home, agricultural, and industrial are estimated using a set of factors in a mathematical equation.

The most reliable instrument for analysing water quality is the water quality index (Omer, 2020). An important instrument for chemically assessing water quality is the water stability index. The capacity of water to dissolve or deposit minerals, which varies depending on its chemical composition, is referred to as water stability. Furthermore, water stability can affect water quality by allowing certain metals like chromium, arsenic, and lead to seep into the water, making the water corrosive or allowing bacteria to flourish if the water is scaling. As a result, water stability is significant as a public health concern as well as a financial one for water distribution infrastructure.

The residential neighbourhood surrounds KotaSAS Lakeside. As a result, there is no possibility of algal growth. The eutrophication process is speeding up due to current human activities such as sewage runoff and agricultural runoff into water bodies. These plants capacity to remove a variety of parameters, including pH, temperature, BOD, COD, DO, TSS, Turbidity, Nitrite, and heavy metals, in addition to nutrients. Considering the issues, the current study was undertaken to determine the amount of pollution and the state of the water in the study region. Standard Method for Examination of Water and Wastewater referred to a procedure for investigating lake water.

2.2 Man Make Lake versus Natural Lake

In various respects, man-made lakes vary from natural lakes. Reservoir drainage basins are often substantially bigger than natural lake drainage basins in terms of lake surface area. Because reservoir basins are most typically developed in river valleys, they are narrow, elongated, and dendritic (branching). Reservoirs receive runoff from big streams and rivers, and they are seldom absorbed by marshes or shallow interface zones. As a result, runoff inputs are greater, more directly tied to rainfall, and influence a bigger area of the lake than in most natural lakes. In wet weather, these traits result in substantial nutrient and sediment inputs.

Natural lakes are found in the headwaters of rivers or streams, whereas man-made lakes are found around the river's or stream's mouth. As a result, nutrient and sediment concentrations in natural lakes are often lower than in man-made systems. Natural lakes have relatively stable water levels, whereas reservoirs have water levels that are often regulated for flood control, hydropower generation, and/or navigation. Reservoirs regularly release water from the dam pool's bottom, which contains little dissolved oxygen, posing a threat to downstream water quality. The surface waters of natural lakes, on the other hand, are usually well-aerated.

The continuous manipulation of reservoir water levels precludes the growth of stabilising wetlands and shoreline vegetation and promotes coastline erosion and sediment loading. Flooding and exposure occur often, which may cause sediments to release more nutrients than natural lakes. The increased nutrient load promotes the growth of algae and other creatures, which eventually die and sink to the sediments. The reservoir progressively fills with sediments, reducing its lifespan compared to natural lake systems.

2.3 Parameter of Water Quality

Water quality metrics include chemical, physical, and biological qualities that can be evaluated or monitored depending on the water parameters of concern. Each attribute has its own identifying measurement. Depending on the kind and level of pollution, a variety of techniques can be employed to clean up waste waters.

2.3.1 pH

pH is an established value based on a specified scale. This implies that the pH of water is not a physical property that can be measured as a concentration or amount. Instead, it is a number between 0 and 14 that indicates how acidic or basic a body of water is on a logarithmic scale. The lower the value, the more acidic the water. The greater the number, the more fundamental it is. A pH of 7 is considered neutral. Because of the logarithmic scale, each number below 7 is 10 times more acidic than the preceding number while counting down. Similarly, while counting from 7, each number is 10 times more fundamental than the previous number. Fish and aquatic plants rely on the pH level of a lake or stream to survive.

Typically, the pH of freshwater lakes and streams is between 6.0 and 8.0. The pH near the surface of deeper lakes is often higher pH fluctuations influence aquatic creatures. **Error! Reference source not found.** shows the ideal pH for fish, for e xample, is between 6.5 and 9.0. Fish become poisoned by hazardous substances when their levels go outside of this range. Changes in pH can also result in an overabundance of accessible plant nutrients, resulting in excessive plant growth and oxygen depletion in fish. Eutrophication is a state that puts plant and animal life in the water at risk of extinction.

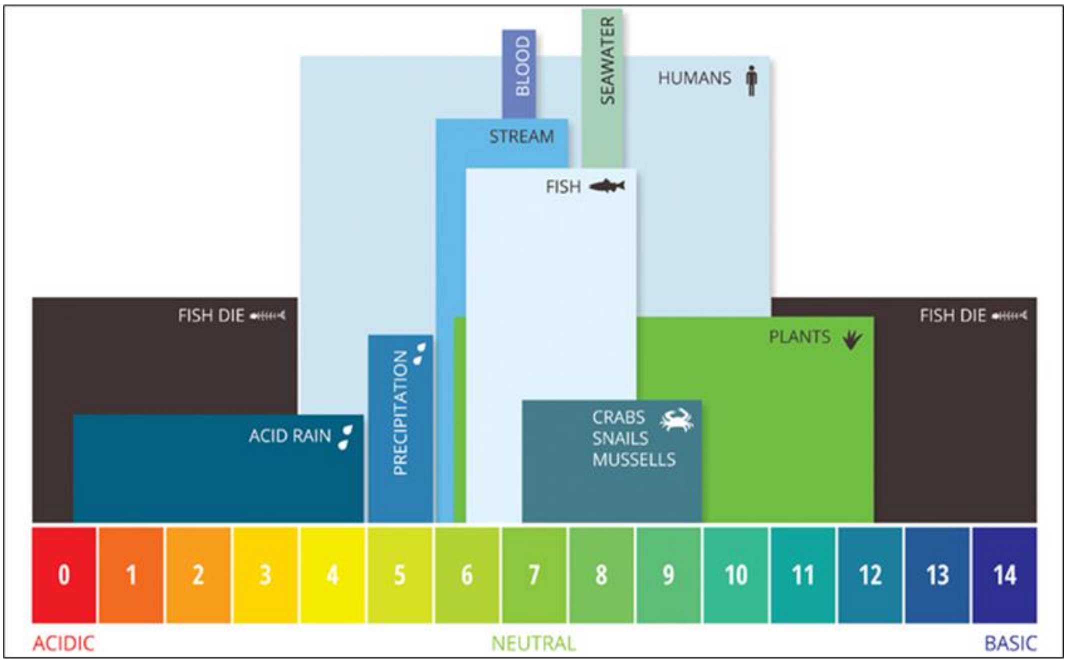


Figure 2. 1 pH scale

Source: Portal FONDRIEST Environmental Learning Center (2022).

2.3.2 Temperature

Waters temperature is one of its most fundamental qualities, and the precision of many other parameters is dependent on it. Researchers can monitor thermal loading or discharge and assess changes in the thermocline using temperature data, which has an impact on aquatic species and creatures' health. High temperatures are harmful to a variety of aquatic creatures. Warmer water has a decreased oxygen solubility, decreasing the amount of oxygen available.

2.3.3 Turbidity

Water clarity is measured by turbidity. Suspended sediments, such as clay, dirt, and silt, enter the water from disturbed areas and have an impact on water quality.

Pollutants like as phosphate, pesticides, and heavy metals can be found in suspended sediments. Suspended particles reduce the depth of light penetration through water, increasing turbidity (or "murkiness" or "cloudiness"). The sort of flora that develops in water is affected by turbidity. Turbidity of water can reveal details about the health or well-being of the water body. It is crucial to remember that excessive turbidity does not always signal the water body is in trouble. Short-term turbid "events" may be transient and have little overall influence on the system, whereas long-term turbid "events" may be permanent and have little overall effect on the system.

2.3.4 Biochemical Oxygen Demand (BOD)

BOD (biochemical oxygen demand) is a chemical process for estimating the quantity of dissolved oxygen required by aerobic biological organisms in a body of water to break down organic material contained in each water sample at a particular temperature during a certain period. BOD is an essential water quality metric since it serves as an index for determining the impact of discharged wastewater on the ecosystem. Temperature, pH, the presence of specific types of bacteria, and the kind of organic and inorganic material in the water all influence the rate of oxygen consumption. The higher the number, the faster the water loses oxygen. Higher types of aquatic life will have less oxygen accessible as a result. Aquatic creatures get stressed, suffocate, and die because of elevated BOD. Animal manure; effluents from pulp and paper mills, wastewater treatment facilities, feedlots, and food-processing industries; failed septic systems; and urban stormwater runoff are also sources of biochemical oxygen demand.

2.3.5 Chemical Oxygen Demand (COD)

The amount of dissolved oxygen required to oxidise chemical organic compounds is known as chemical oxygen demand (COD). COD is a metric for determining the short-term influence of wastewater effluents on oxygen levels in receiving waterways. When treated wastewater is released into the environment, it can pollute receiving waterways by introducing organic material. High levels of COD in wastewater indicate high quantities of organics in the water, which can deplete dissolved oxygen and have significant environmental and regulatory effects. Oxygen demand is a crucial metric for determining the impact and, eventually, limiting the quantity of organic pollutants in water.

2.3.6 Dissolved Oxygen (DO)

The amount of free, non-compound oxygen contained in water or other liquids is referred to as dissolved oxygen. Because of its impact on the creatures that live in a body of water, it is a crucial metric in determining water quality. Dissolved oxygen is the second most important component in limnology (the study of lakes) after water itself. Too much or too little dissolved oxygen can damage aquatic life and degrade water quality.

2.3.7 Total Suspended Solid (TSS)

TSS stands for total suspended solids, which are aqueous particles larger than 2 microns. A fully dissolved solid, on the other hand, is defined as any particle less than 2 microns (TDS). Most total suspended solids are made up of inorganic elements, however algae and bacteria can also be included. TSS can be sand, silt, or plankton, as well as anything else that floats or "suspends" in water. The organic particles discharged into the water when some water sources are polluted with rotting plants or animals are generally suspended solids. While some sediment settles at the bottom of a water source, TSS floats on the surface or remains suspended somewhere in the middle. TSS influences the purity of water, hence the greater the TSS level of a water source, the less clear the water will be.

2.3.8 Iron (Fe)

Some soil and rocks contain iron-rich minerals. Iron may be absorbed into water as rain or snow falls on the ground surface and water seeps through iron-bearing soil and rock. Iron can also be caused by corrosion of iron or steel well casings or water pipelines in rare circumstances. Iron minerals in water rust and stain plumbing fixtures and clothes in the same way as iron in a metal pipe rust when exposed to water and oxygen.

2.3.9 Aluminium (A1)

Aluminium is a plentiful element that is commonly found in home equipment (Sander et al.,2018). Aluminium is also a frequent coagulant in water and wastewater treatment (Aljerf, 2018). The widespread use of aluminium generates a considerable amount of aluminium garbage. Some types of aluminium waste include dross, slag, scrap, and foil. Some signs of aluminium pollution include groundwater colour change (Kurniawan et al., 2018), decreased soil fertility (Titah et al., 2019), and fish death.

2.3.10 Manganese (Mn)

Manganese is required for the synthesis of arginase and glutamine synthetase, as well as superoxide dismutase, a crucial antioxidant mitochondrial enzyme. While manganese is an important mineral, it can produce neurotoxicity at high doses and has been linked to bad neurodevelopmental outcomes in children. Manganese is naturally present in many surface waterways and groundwater sources, as well as soils that erode into these bodies of water. However, human activities are also to blame for a significant quantity of manganese pollution in some places' water (Crapnell, 2022).

2.3.11 Ammonia Nitrogen (NH3)

With the development of industrial scale and intensification of human activities in recent years, emissions of residential sewage and industrial wastewater containing ammonia nitrogen have grown quickly. If ammonia nitrogen-containing wastewater is dumped into an aquatic ecosystem, it can promote eutrophication and create hazardous chemicals. Ammonia also increases chlorine consumption for water disinfection and industrial circulating water sterilising treatment. As a result, it is critical to eliminate ammonia nitrogen during wastewater treatment, which might increase the complexity and expense of the treatment.

2.4 Wastewater Standard Referred by Interim Water Quality Standard Malaysia

Water quality standards outline the criteria that water must achieve to safeguard those specified applications. Measuring lakes and rivers against water quality standards reveals which bodies of water require restoration and preservation, as well as how we establish limitations on pollution releases from public and private facility. As shown in Appendix A, the standard of water quality can be set by referring this water quality standard.

2.5 Phytoremediation

Phytoremediation is an emerging technique that uses chosen plants to clean up polluted environments and enhance environmental quality. Phytoremediation is the process that use of plants for in situ treatment of toxins from soil and solutions, is a promising technology for dealing with pollutants. It is a cost-effective and environmentally friendly method that may supplement or replace traditional procedures. Metal-accumulating plants are used in phytoremediation to recover polluted primary sources such as soil and water (Muthusaravanan et al.,2018). Phytoremediation refers to a class of new approaches that employ plants and their partners to extract, collect, immobilise, or convert toxins from soil microorganisms (**Error! Reference source not found.**).

Phytoremediation entails using plants, algae, and fungi to either remove and control wastes or to stimulate waste breakdown by microorganisms in the rhizosphere. The associated subject of bioremediation is founded only on remediation based on heterotrophic microorganisms. However, these critical biological communities do not function in isolation, and hence one essential kind of phytoremediation is the utilisation of plants to promote increased heterotrophic breakdown by rhizosphere bacteria.

Organic and heavy metals absorption using phytoremediation technique encompasses numerous processes such as Phyto stabilization, rhizodegradation, phytoextraction, phytodegradation, phytoaccumulation, and phytovolatilization (Tangahu et al., 2011). Exudates from root plants stabilise, demobilise, and bind pollutants in the soil matrix, limiting their bioavailability. This is referred to as the phytostabilization process. Certain plant species have exploited absorption and accumulation by roots, adsorption onto roots, or precipitation within the root zone to immobilise pollutants in the soil and ground water. This method is used to remove organic and metal pollutants from soils, sediments, and sludges.

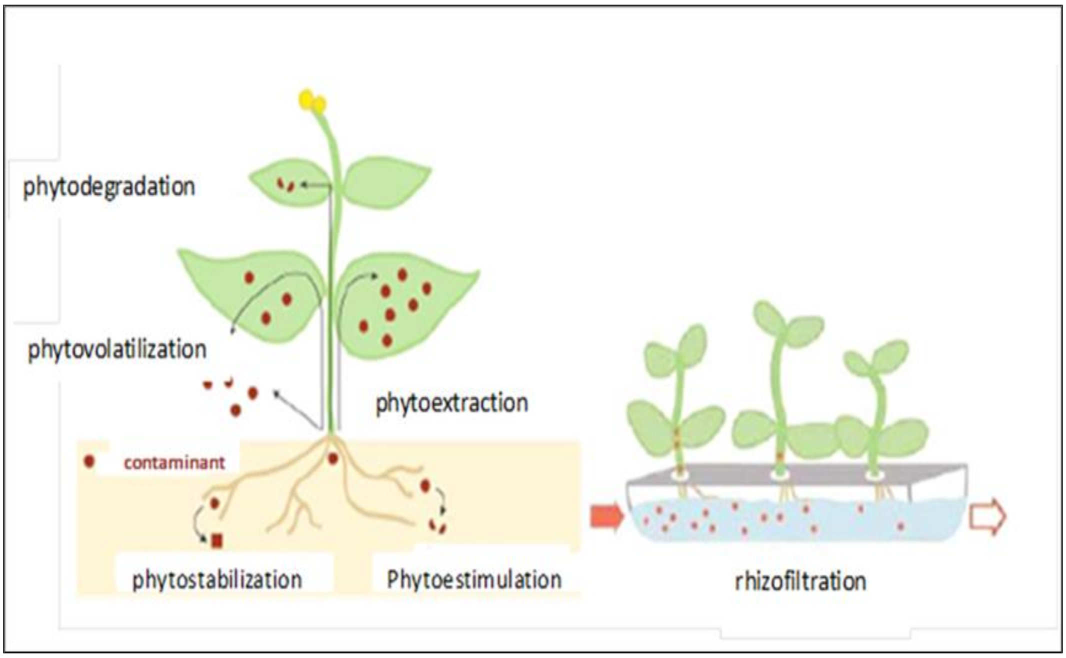


Figure 2. 2 Schematic representation of the different mechanism of phytoremediation

Source: Annual review of plant biology (2005).

2.5.1 Mechanism of Phytoremediation

One of the biological strategies for remediating contaminated environments in situ is phytoremediation. Phytoremediation uses plants to turn wastewater into useable water. The techniques are used in wastewater treatment, surface water and groundwater purification, the removal of excessive nutritive substances from water reservoirs, and the restoration of soil that has been contaminated by environmental disasters. This method tries to take use of plants capacity to adsorb, ingest, concentrate, or metabolise organic xenobiotics, as well as their ability to generate root exudates that aid in biotransformation and microbial destruction of those organics. The practise of cultivating plants to remove pollutants from the environment, known as phytoremediation, is a potential approach for environmental remediation (Sarma et el., 2021). Phytoextraction, phytodegradation, phytovolatilization, hypofiltration (phytofiltration), and phytostabilization are all part of the phytoremediation process. The following sections provide more information:

Phytoextraction: It also known as phytoaccumulation, is a process in which toxic metals are absorbed by plant roots, transported to shoots, and deposited in vacuoles, cell walls, cell membranes, and metabolically dormant portions of plant tissue. Plants are collected in contaminated environments. Plants chosen for phytoextraction should be resistant, meaning they can survive and accumulate higher quantities of metals or hazardous compounds in their root and shoot tissues.

Phytodegradation: Plants digest and remove pollutants in their tissues through a process called phytodegradation. Various plant components that breakdown or change organic contaminants, such as pesticides, can repair them. Plant components, either directly or indirectly, can play a significant influence in phytodegradation. Organic materials and contaminants are broken down by metabolic processes or plant metabolites. Through metabolites such as nitro reductase, dehalogenase, and oxygenase, these plants break down organic compounds in the environment.

Phytovolatilization: Contaminants from the soil or water are absorbed by the plant roots, which are subsequently translocated to the aerial parts, and lastly to the leaves, where they are converted into volatile form during metabolic processes and then transpired.

Rhizofiltration (phytofiltration): Surface contaminated water is treated using this technology. The polluted water is sprayed on the root’s surfaces, or the plants are soaked in treated water. As a result, the plants utilised in this approach must be very tolerant to hazardous substances, resistant to low oxygen levels, and have a huge root system that develops quickly and generates enormous amounts of biomass.

Phytostabilization: It is the process of immobilising pollutants in the soil/water by accumulating and adsorbing them in the roots or rhizospheric zone of plants. Plant roots inhibit pollutant transport in this process, allowing them to be disseminated by erosion or water movement.

This process may be carried out with a wide variety of plant species. Plants use one or more of these processes to lower their water concentrations, depending on the pollutants. Depending on the pollutant kinds, forms, and medium, different plants utilize various strategies or combinations of approaches to remediate soil and water. Phytoremediation is an emerging clean-up solution for polluted soils, groundwater, and wastewater that is environmentally friendly, non-toxic, low-tech, and low-cost.

2.6 Selected Plant for Phytoremediation

The water status of plants is determined by the balance of water transpiration and the presence of specific harmful heavy metals ions, the concentration of which influences plant hydration by hindering water intake and modifying stomatal conductance. Plants with high biomass, increased removal efficiency, a fibrous root structure, and greater tolerance for metal absorption are often the best choices for phytoremediation.

2.6.1 Lepironia Articulata Sp. (Purun/Kercut)

Because it is plentiful in natural wetlands and simple to reproduce, an evergreen perennial Malaysian plant species (*Lepironia articulata*; locally known as "kercut") was chosen for this study. This native sedge is a clump-forming emergent water plant. It has a massive root system that is well-anchored. The stems of this species are slender, blue-green, and taper to a point at the tip. A pinecone-like inflorescence appears 2-3 cm below the stem tip on each stem. Emerging dragonflies can perch on the stems before taking flight. It has the potential to spread quickly and cover enormous parts of a landscape. The roots are used ethnobotanically to trap sediments in the water and absorb lead that accumulates in the plant tissues.

Figure 2. 3 *Lepironia Articulata Sp.* Plant; (a) the flower of plants and (b) the steam of plants

Source: National Park Flora and Fauna (2021).

2.6.2 Typha Angustifolia

Temperate drainage and irrigation channels, related reservoir and pond systems, navigation canals, and natural freshwater and wetland systems all have *T. angustifolia* as a plant (lakes, rivers, ponds, topogenous and soligenous mires, fens, and other marsh systems). It tends to develop monodominant stands in ideal settings for growth because of its clonal growth pattern and great competitive abilities. *T. latifolia* has many of the same habitats as *T. angustifolia*, however in waters deeper than 15 cm, it is often replaced by *T. angustifolia*. Under normal circumstances, neither species can live in water deeper than 60-80 cm. Salinity tolerance is low in both plants, with only weakly brackish conditions tolerated. Even 1% salinity causes leaf damage in *T. latifolia*, while there is some evidence in North America that *T. angustifolia* is somewhat more salt-tolerant than *T. latifolia*. The plants require soils with a pH of >5.5 and are not found in more acidic soils.

Figure 2. 4 *Typha Angustifolia plant ;*(a) the flower of plant and (b) the steam of plants

Source: National Park Flora and Fauna (2021).

2.7 Conclusion

The studies of industry and its treatment in a global perspective are covered in this chapter. The presence of excessive BOD, COD, TSS, DO, pH, turbidity, and nitrite suggest that organic wastes have been discharged. Phytoremediation water treatment is significant because it is cost-effective, environmentally friendly, and environmentally friendly. It is also a good and crucial technique for improving lake water treatment. Phytoremediation enables for in-situ treatment, resulting in less environmental disruption. With its rapid-growth root structure, a good plant for phytoremediation applications may remove harmful metals from solution for a long length of time.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Methodology is a set of fundamental principles or laws that may be utilised to create ways and procedures for understanding and solving problems. It also contains lake water treatment methods via theoretical and experimental examination of lake water samples obtained before and after plant rehabilitation, sampling method and experiment method. The source of lake water for this study is located at KotaSAS Lake, Kuantan, Pahang. In other words, this investigation will be reported in a well-planned sequence from start to finish. As a result, the approach will concentrate on the process of aquatic plant selection and lake water sampling, as well as procedures and tests throughout the research to archive study project objectives.

3.2 Research Flow Chart

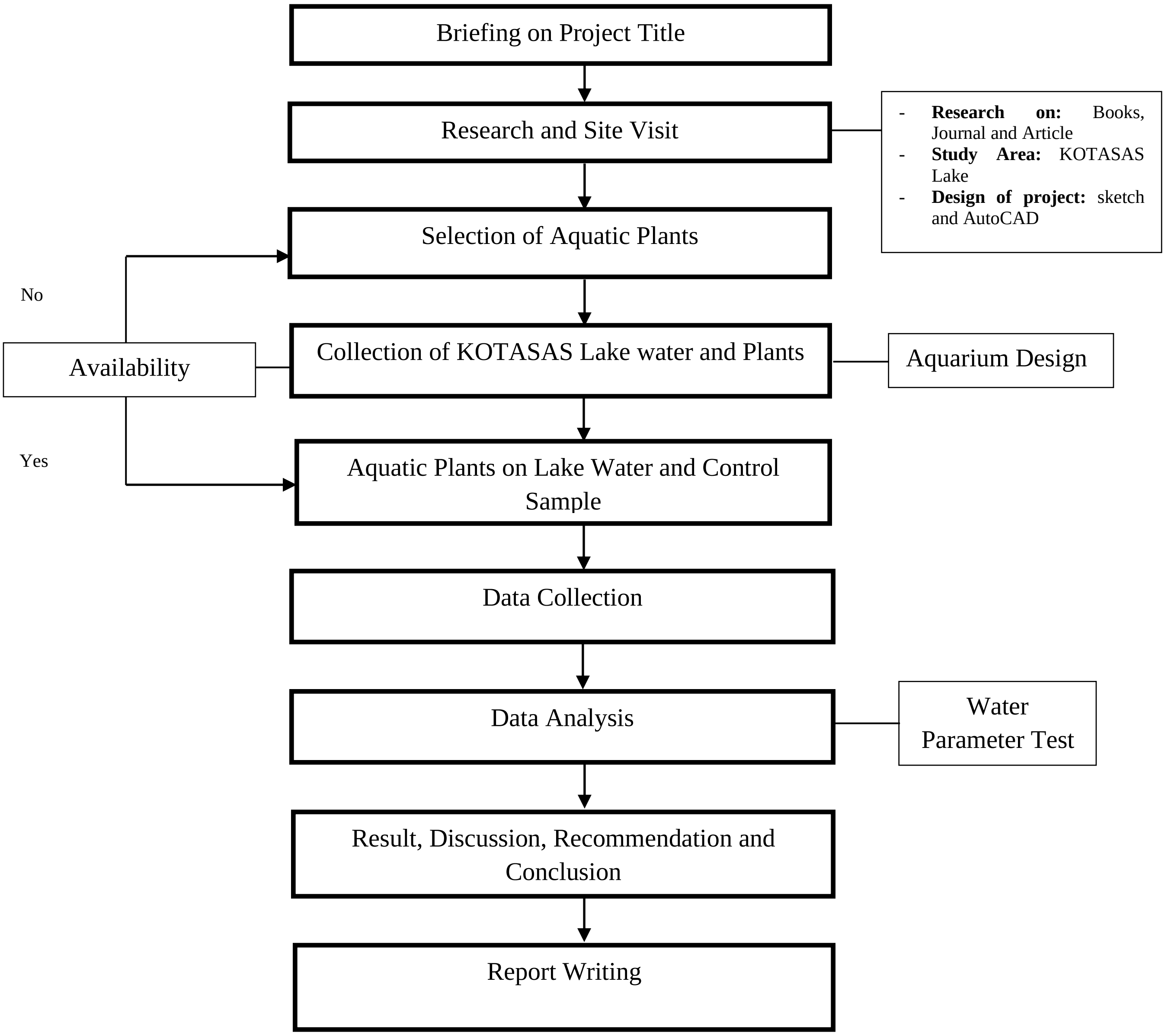


Figure 3. 1 Flow chart of this project

3.3 Study Area

Figure 3.2 shown that the location of KotaSAS. KotaSAS is a township in Kuantan, Malaysia, around 10 kilometres from the city between coordinates of 3.8722° N, 103.2727° E. The sampling collection was collected at 3 main discharge point that has been shown in figure 3.3. KotaSAS is Kuantan's largest township developer, delivering a fully integrated development with high-quality residential and commercial developments. KotaSAS has been named "The Best Integrated Township Development-ASEAN Property Developers Awards 2019/2020" for its future-focused and well-curated masterplan. With a population of 30,000 people, the township project plans to create around 6,000 residential units. Quality mixed units of connected, duplex, semidetached, and bungalows, ranging from 1 to 2.5 storey structures, are available in KotaSAS residential stages to meet the needs of KotaSAS educated and professional citizens.

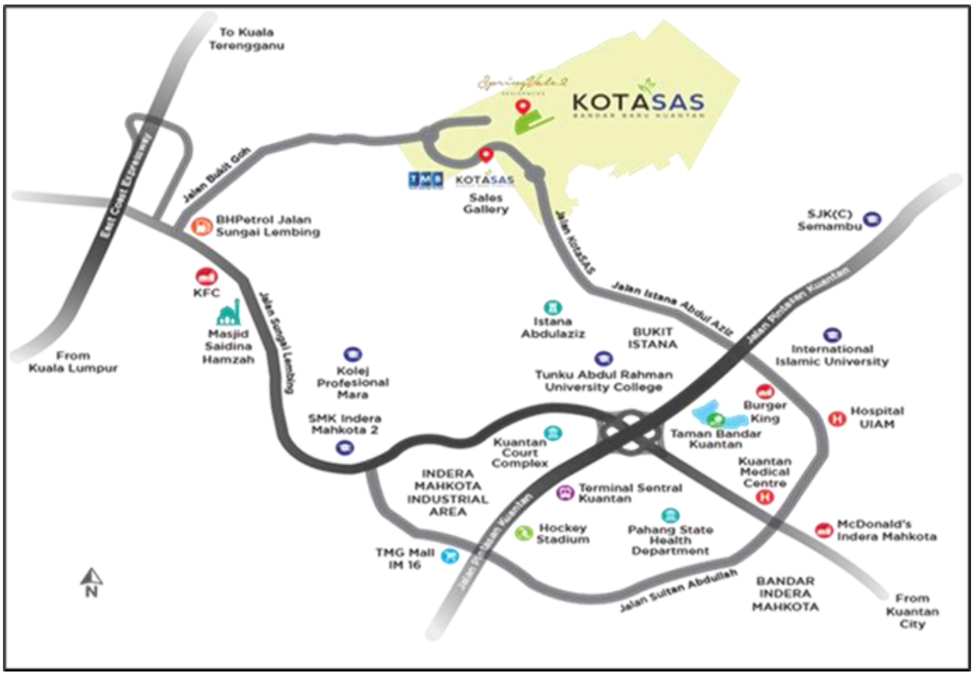


Figure 3. 2 *KotaSAS location*
Source: Sales Gallery KotaSAS (2022).

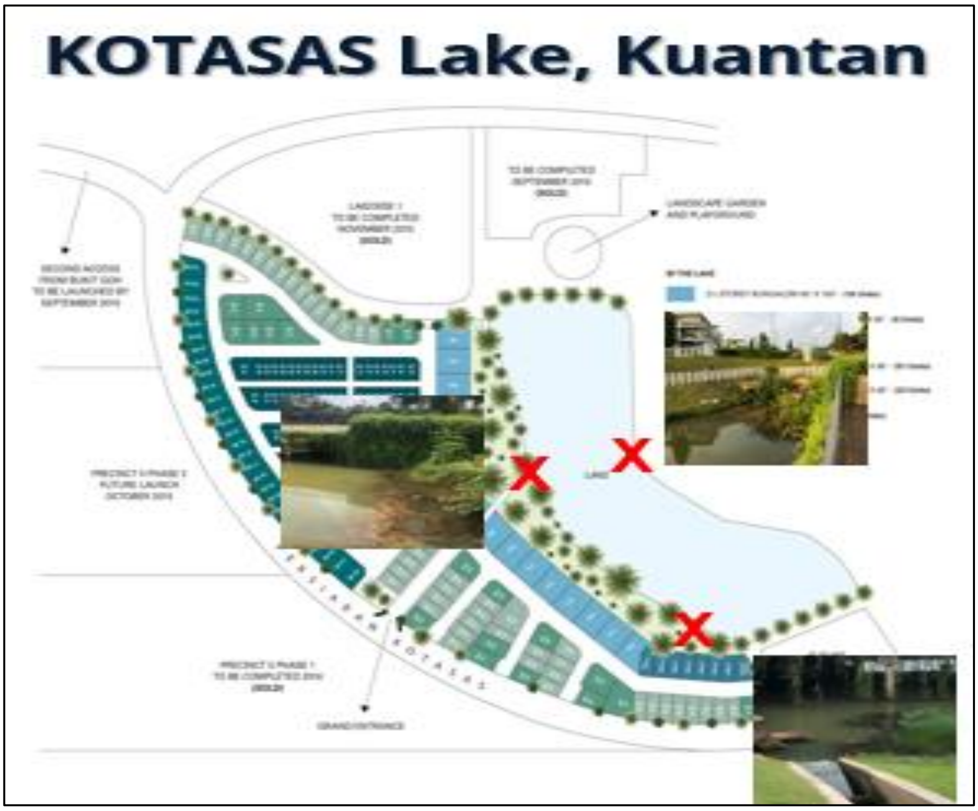


Figure 3. 3 Location of discharge point at *KotaSAS Lake*
Source: Sales Gallery KotaSAS (2022).

3.4 Sampling Methodology

Sampling is essential for obtaining accurate data on water quality. The wastewater from KotaSAS Lake will be pumped into the tank first. The lake water will next be spread among two tanks (Tank A and Tank B). The first phase of tank will represent lake water, the second tanks will be tanks with various types of aquatic plants, and the third tank will represent the lake's outflow. The therapy will take place in these three phases of tanks for each plant. The second container will be treated with *Lepironia Articulata* plants for tank A, and the tank B with *Typha Angustifolia* plants. The sample will take place once a week for the next 5 weeks. This sampling will consist of 5 samples from tank A and 5 sample from tank B. Each sample will be tested for the 10 parameters listed below: Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), pH, Temperature, Turbidity, Iron (Fe), Manganese (Mn), Nitrate (NO3) and Aluminium (Al).

3.4.1 Location and Geography

Wastewater was collected at the KotaSAS lake region, which is located at 3.8722° N, 103.2727° E. Clean bottles and containers that had been cleaned with distilled water were used to collect the effluent. The samples are then placed in the main tank. After that, all samples are instantaneously determined.

Figure 3. 4 *KotaSAS location*

3.4.2 Plant Collection

Typha Angustifolia was found in Gebeng, Kuantan, whereas *Lepironia Articulata* was found near Black Water Jewel in Felda Runchang. Using purified water, the plants were cleaned. In a few tanks, the samples were maintained in distilled water for a few days. The plant was then placed in a tank. For this experiment, the tanks are positioned at behind Environmental Laboratory at FTKA Building.

(a) (b)

(c)

(d)

Figure 3. 5 Lepironia Articulata Plan; (a) the location of plant that has been found at *Black Water Jewel, Felda Runchang,* (b) the steam of the plants , (c) the collection of plants by technical staff and (d) the flower of this plants.

3.5 Method of Experiment

Assessment activities include lake water sampling to identify influent and effluent pollutant loads or concentrations, as well as treatment procedure performance. Sampling can be done in situ, with grab samples, or with automatic sampling equipment, depending on the water quality parameter of interest. Samples can alternatively be taken on a time-weighted or flow-weighted basis (equal time between samples) (equal volume of flow passing the sampling site between samples). This section examines the various sampling methods available and when and how to use them, as well as the number of sampled events necessary to attain a specific confidence interval. There is also a discussion on sample storage and management.

3.5.1 In-situ Method

Before starting the experiment, make sure that the place for the in-situ experiment is properly prepared refer figure 3.6. All the materials specified have been tested to confirm that they fit the standards, and the necessary equipment to construct the experiment site is also available. These are performed to check that the experiment site is properly constructed and that the materials are assembled in accordance with the design. Before the experiment begins, the dimensions are precisely measured, and the complete constructed equipment is inspected.

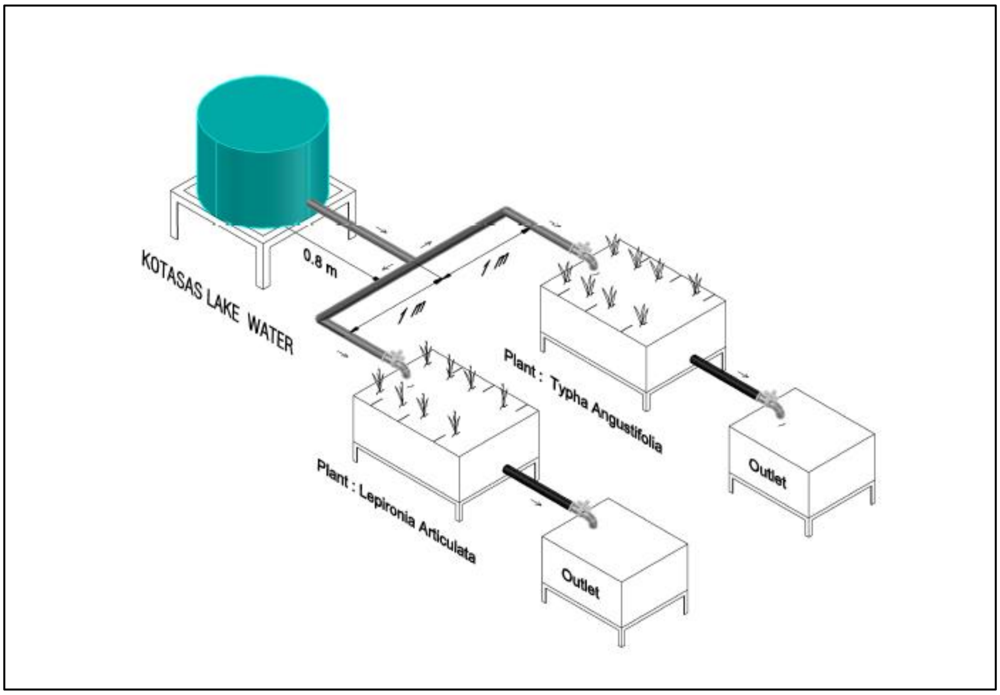
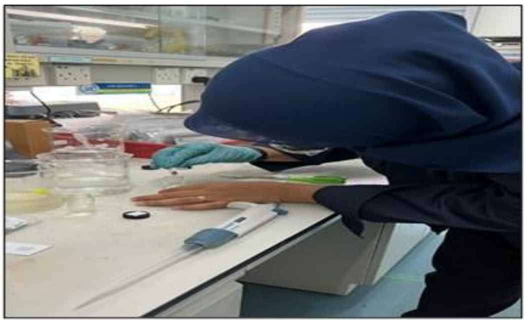


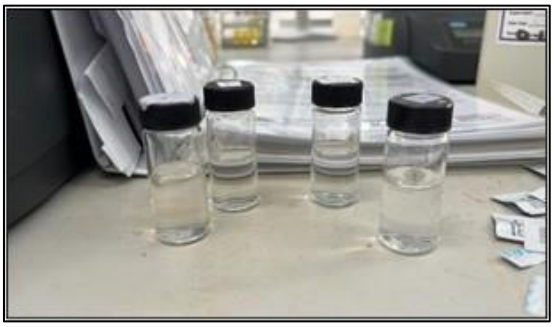
Figure 3. 6 Phytoremediation Plan Drawing Layout

3.5.2 Ex-situ Method

This method will be carried out in the Environmental Laboratory of the Faculty of Civil Engineering and Earth Resources. Depending on the circumstances, this technique might be finished in five weeks to analyse the chemical qualities of wastewater. The parameters include BOD, COD, TSS, pH, temperature, turbidity, manganese, iron, aluminium, and ammonia nitrogen.



(a)



(b)

(c) (d)

Figure 3. 7 *Water Parameter Test at Laboratory;* (a) the experiment of heavy metals using Hech method, (b) the sample for heavy metals testing, (c) COD testing and (d) the turbidity testing.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

Methodology is a set of fundamental principles or laws that may be utilised to create ways and procedures for understanding and solving problems. It also contains lake water treatment methods via theoretical and experimental examination of lake water samples obtained before and after plant rehabilitation, sampling method and experiment method. The source of lake water for this study is located at KotaSAS Lake, Kuantan, Pahang. In other words, this investigation will be reported in a well-planned sequence from start to finish. As a result, the approach will concentrate on the process of aquatic plant selection and lake water sampling, as well as procedures and tests throughout the research to archive study project objectives.

4.2 Characteristics and Parameter of KotaSAS Lake Water

4.2.1 pH

The pH of the KotaSAS Lake Water was measured and recorded from the beginning of the study.

Table 4. 1 Result of pH (pH)

Week	***Typha Angustifolia***	***Lepironia Articulata***
1.	6.85	6.85
2.	6.69	6.14
3.	6.08	5.67
4.	6.29	6.38
5.	6.07	5.96

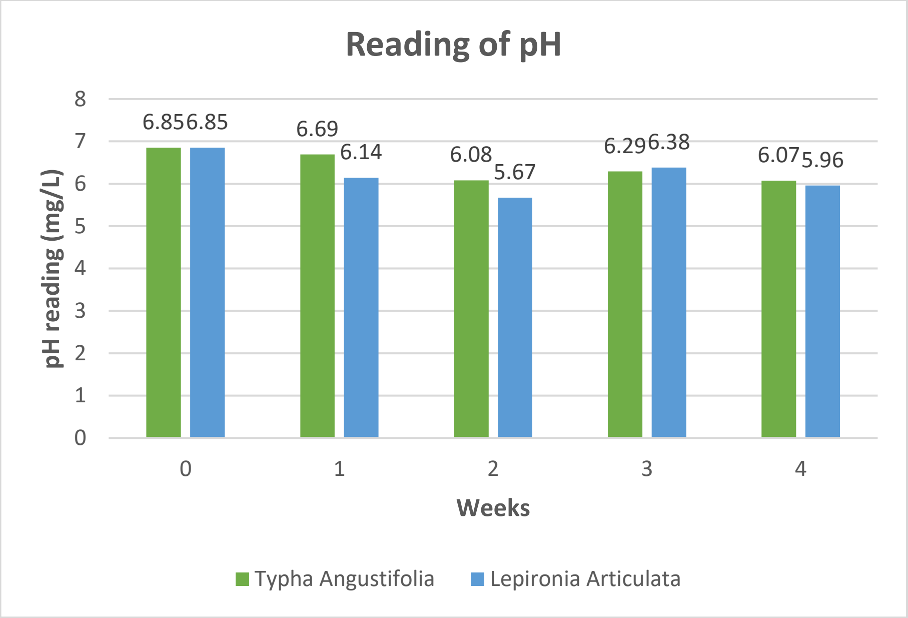


Figure 4. 1 The result of pH test

The pH of water in rivers, lakes, and wetlands is critical for plant and animal life. Most animal species cannot live in water that is either too acidic (usually less than 5.0) or too basic (above 9.0). Many organisms like a pH between 7.0 and 9.0. In five weeks, the pH of samples A and B was measured. The initial pH of the sample was 6.85 without the use of aquatic plants at the beginning of the study. The graph above shows that the pH of each sample decreased in every week and it is still in neutral stages.

4.2.2 Temperature

The temperature of the KotaSAS Lake Water was measured and recorded from the beginning of the study.

Table 4. 2 Result of Temperature (°C)

Week	***Typha Angustifolia***	***Lepironia Articulata***
1.	31.1	31.1
2.	27.9	27.8
3.	33.0	32.2

Week	*Typha Angustifolia*	*Lepironia Articulata*
4.	27.8	28.1
5.	27.0	27.0

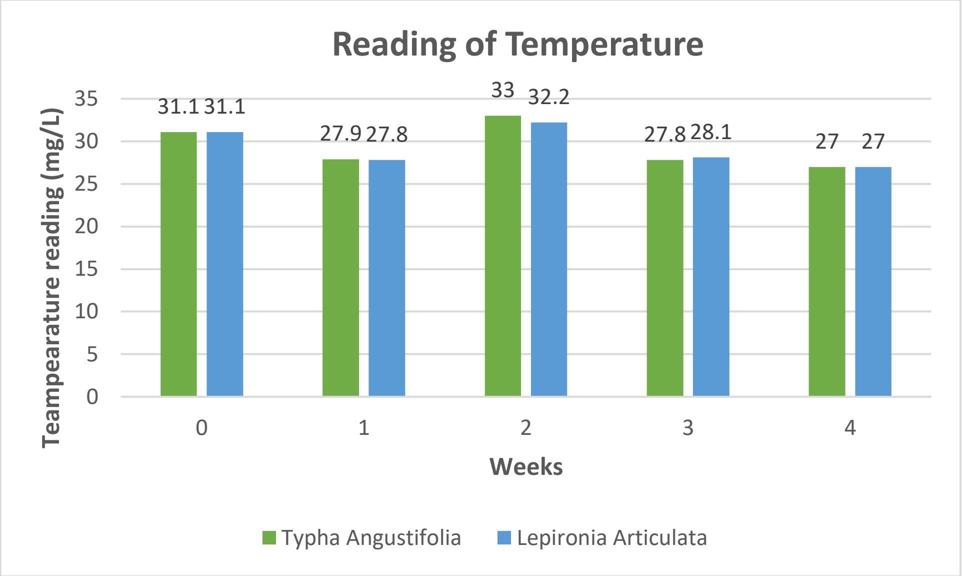


Figure 4. 2 The result of temperature test

Temperature is also significant due to its impact on water chemistry. At greater temperatures, the rate of chemical reactions normally rises. Water at greater temperatures, particularly groundwater, may dissolve more minerals from the surrounding rock and hence has a higher electrical conductivity.

4.2.3 Turbidity

The turbidity of the KotaSAS Lake Water was measured and recorded from the beginning of the study.

Table 4. 3 Result of Turbidity (NTU)

Week	*Typha Angustifolia*	*Lepironia Articulata*
1.	27.8	27.8

Week	*Typha Angustifolia*	*Lepironia Articulata*
2.	20.0	13.8
3.	17.5	12.6
4.	9.24	10.5
5.	5.36	6.72

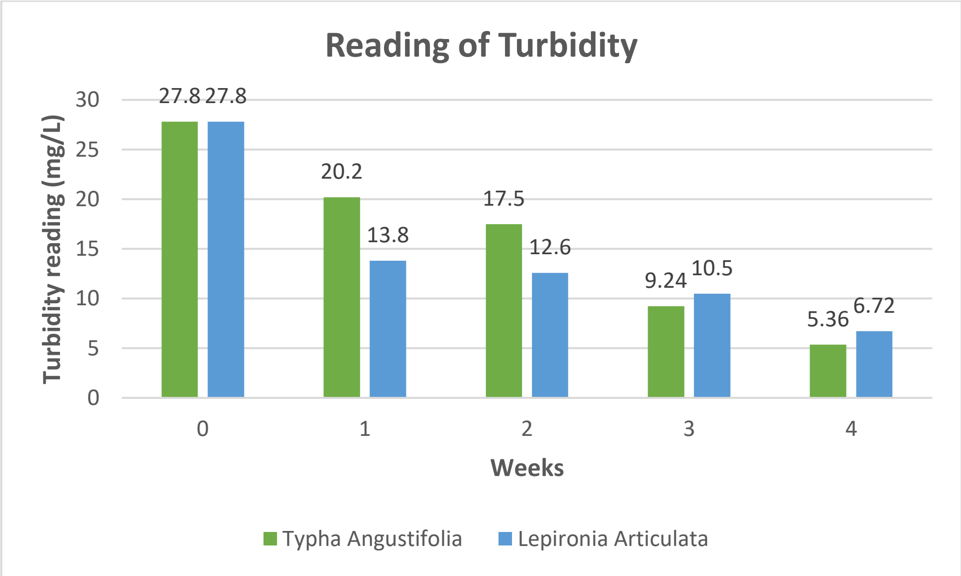


Figure 4. 3 The result of turbidity test

Turbidity is an essential measure of the quantity of suspended material in water, which can have a variety of deleterious consequences on aquatic life. Turbidity is caused by suspended sediments, which may obstruct light to aquatic plants, suffocate aquatic species, and transport toxins and diseases such as lead, mercury, and germs. The results showed that the turbidity level at the beginning of the study for both samples was 27.8 NTU. The turbidity level steadily decreased over the weeks. The lower the turbidity value in the sample water, the higher the clarity of water.

4.2.4 BOD

BOD is defined as the amount of molecular oxygen utilised by the microorganisms in a sample during a certain time period. A high BOD level indicates that there will be less oxygen, and oxygen is critical for aquatic life existence. As a result, elevated BOD levels contaminate the receiving (marine) environment. The Biochemical Oxygen Demand (BOD) test determines how quickly living organisms deplete oxygen in a body of water. The 5-day BOD is the most commonly used organic pollution measure for both effluent and surface water (BOD5). The amount of oxygen needed by microorganisms to break down organic materials in water is measured as BOD5. It is also known as five-day carbonaceous biochemical oxygen demand, which is a measurement of the quantity of oxygen required to biologically stabilized a waste.

The BOD of the KotaSAS Lake Water was measured and recorded from the beginning of the study. Table 4.4 shown that the initial BOD result was 6.60 mg/L. BOD levels were initially high due to the presence of microbes in KotaSAS Lake water. According to the graph, the result of BOD for both samples decreased after utilizing aquatic plants in rhizofiltration process. This is due to the fact that bacteria consume oxygen and degrade waste in samples will resulting in a decrease in BOD levels.

The results indicates that the BOD of effluents by *Typha Angustifolia* remediate was decrease from 6.60 mg/L to 3.30 mg/L. As for BOD using *Lepironia Articulata* also decrease from 6.60 mg/L to 4.20mg/L. *Typha Angustifolia* has shown that it more effective compare to *Lepironia Articulata* plant. Figure 4.4 illustrates that the water quality classification has been compared to the Malaysian Water Quality Index Standard (IWQS). The water quality class has been reduced from class III to class II. Because helpful bacteria consume a major amount of the organic debris, the BOD level decreases throughout treatment. When organic matter is removed, BOD is lowered. The BOD removal graph shows that the percentages removed for both plants increase every week following the rhizofiltration procedure. As a result, the usefulness of aquatic plants has been demonstrated.

Table 4. 4 Result of BOD (mg/L)

Week	***Typha Angustifolia***	***Lepironia Articulata***
1.	6.60	6.60
2.	5.05	6.45
3.	4.95	5.64
4.	4.10	4.65
5.	3.30	4.20

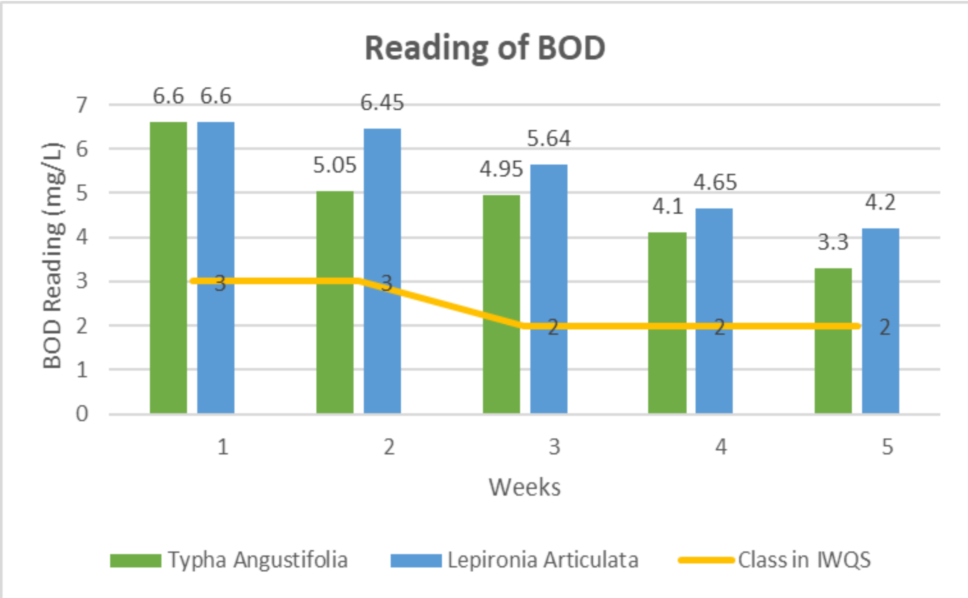


Figure 4. 4 The result of BOD test

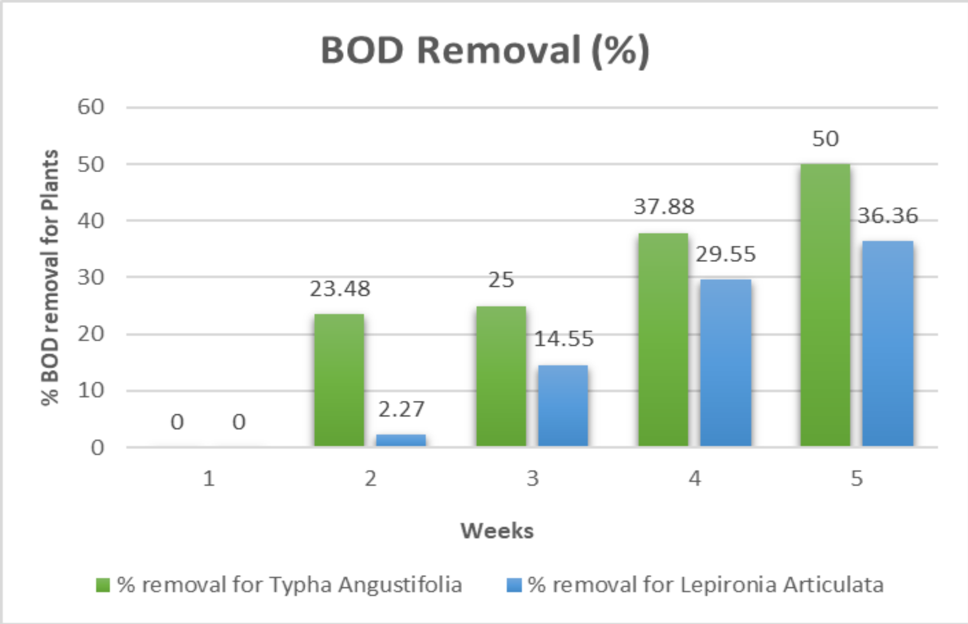


Figure 4. 5 The result of percent BOD removal.

4.2.5 COD

The COD of the KotaSAS Lake Water was measured and recorded from the beginning of the study (table 4.5). The COD level was 130mg/l at the beginning of the study. The COD level in all of the samples continuously decreased until the experiment was completed. The reduction of dissolved oxygen, which causes anaerobic conditions and lowers COD levels. COD is reduced during the aeration process by allowing microorganisms to break down organic molecules in water. These bacteria, known as heterotrophic bacteria, utilise oxygen to break down organic substances.

According to Figure 4.6, the COD level has been decreasing every week. When the first lake water enters the treatment, which is at the influent section, the COD level is at its maximum. The quick decline from week 1 to week 2 is related to the action of microorganisms in the lake water. Using this treatment, COD can be removed at a rate of more than 90% in figure 4.7.

Table 4. 5 Result of COD (mg/L)

Week	*Typha Angustifolia*	*Lepironia Articulata*
1.	130	130
2.	36	23
3.	20	15
4.	16	18
5.	10	11

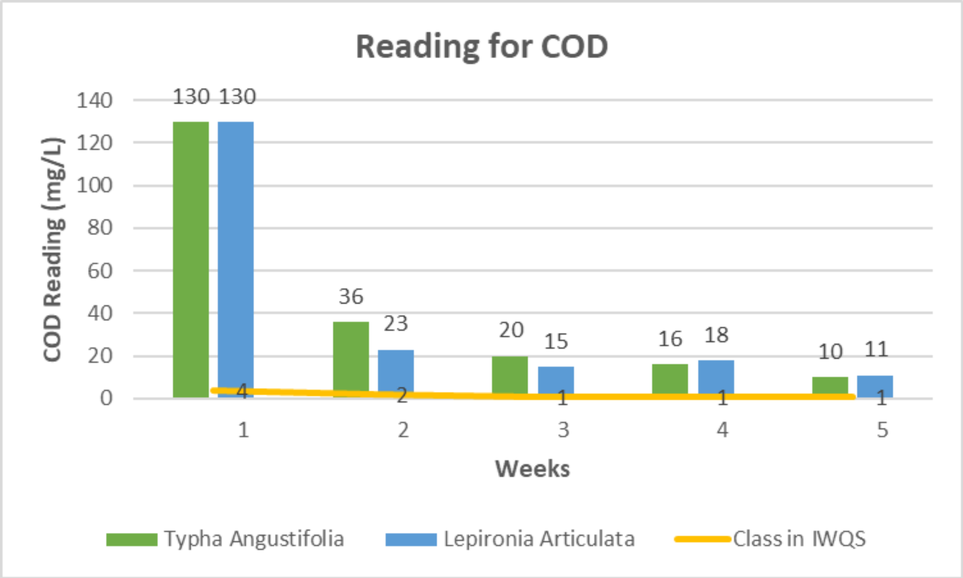


Figure 4. 6 The result of COD test

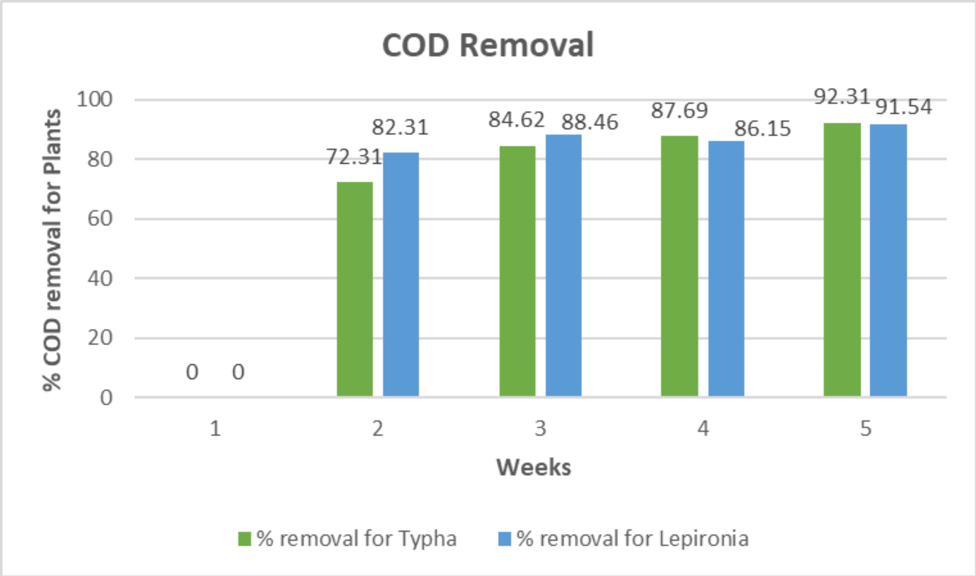


Figure 4. 7 The result of percent COD removal.

4.2.6 TSS

The TSS of the KotaSAS Lake Water was measured and recorded from the beginning of the study in table 4.6. TSS is a water quality measure used to assess the quality of any type of water or water body, such as wastewater after treatment in a wastewater treatment facility. The initial TSS value from this experiment is 75mg/l. The graph shows that the result of TSS decreases every week (figure 4.8).

Figure 4.8 shows that total suspended solids have been effectively classified as Class I in IWQS at the last of treatments. This is related to a decrease in the natural dissolved oxygen level and an increase in water temperature. According to the percentage's removal graph in figure 4.9, the efficacy of eliminating TSS reached 94.67% for Typha *Angustifolia* plants and 93.33% for *Lepironia Articulata* plants.

Table 4. 6 Result of Total Suspended Solid (mg/L)

Week	***Typha Angustifolia***	***Lepironia Articulata***
1.	75	75
2.	47	49

Week	*Typha Angustifolia*	*Lepironia Articulata*
3.	17	26
4.	9	8
5.	4	5

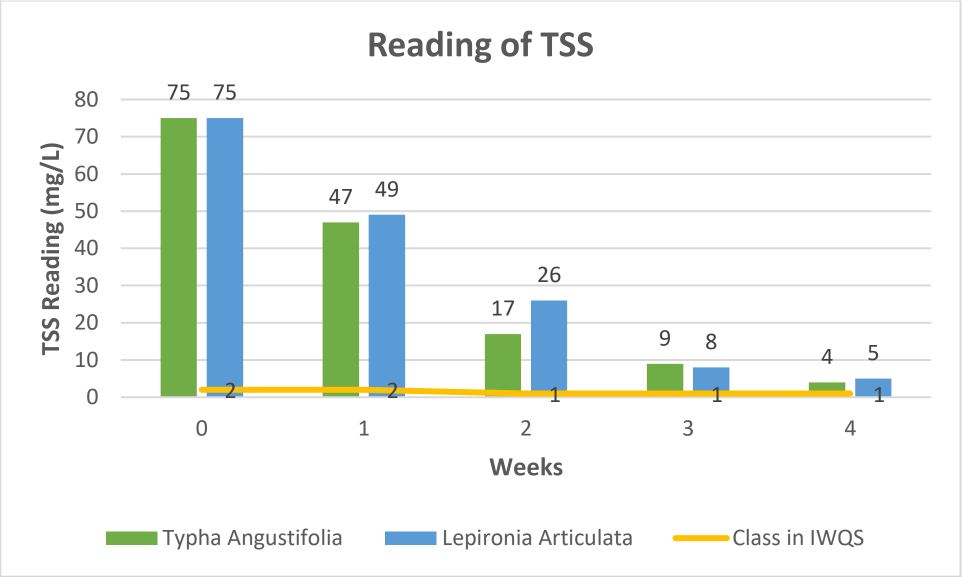


Figure 4. 8 The result of TSS test

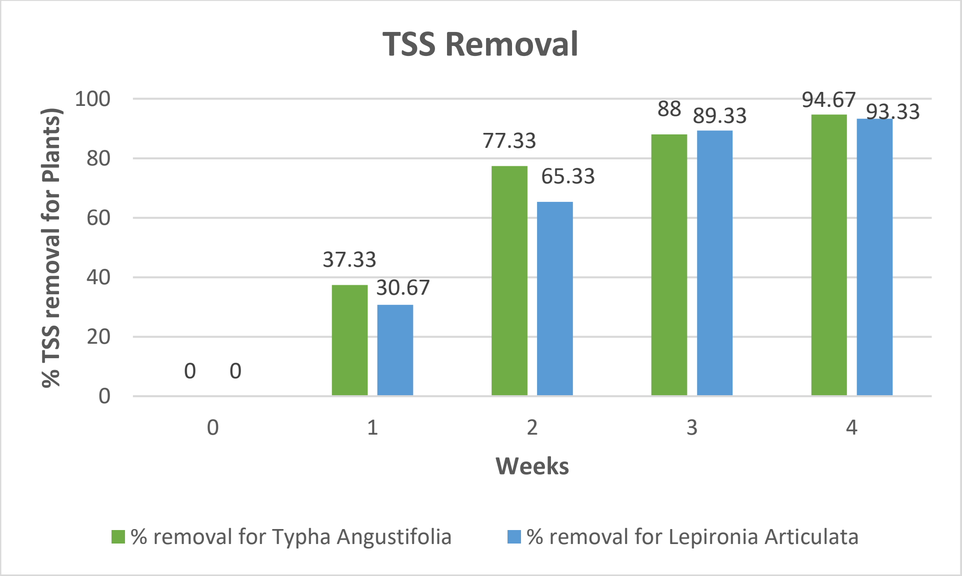


Figure 4. 9 The result of percent TSS removal

4.2.7 Ammonia Nitrogen (NH3)

The Ammonia Nitrogen of the KotaSAS Lake Water was measured and recorded from the beginning of the study.

Table 4. 7 Result of Ammonia Nitrogen (mg/L)

Week	***Typha Angustifolia***	***Lepironia Articulata***
1.	0.60	0.60
2.	0.05	0.09
3.	0.01	0.05
4.	0.01	0.03
5.	0.01	0.02

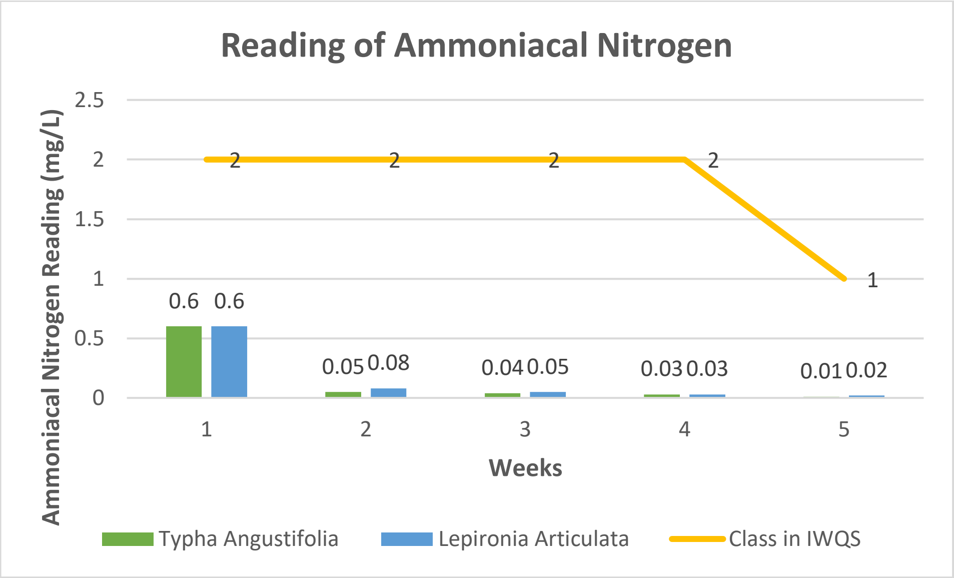


Figure 4. 10 The result of Ammoniacal Nitrogen test

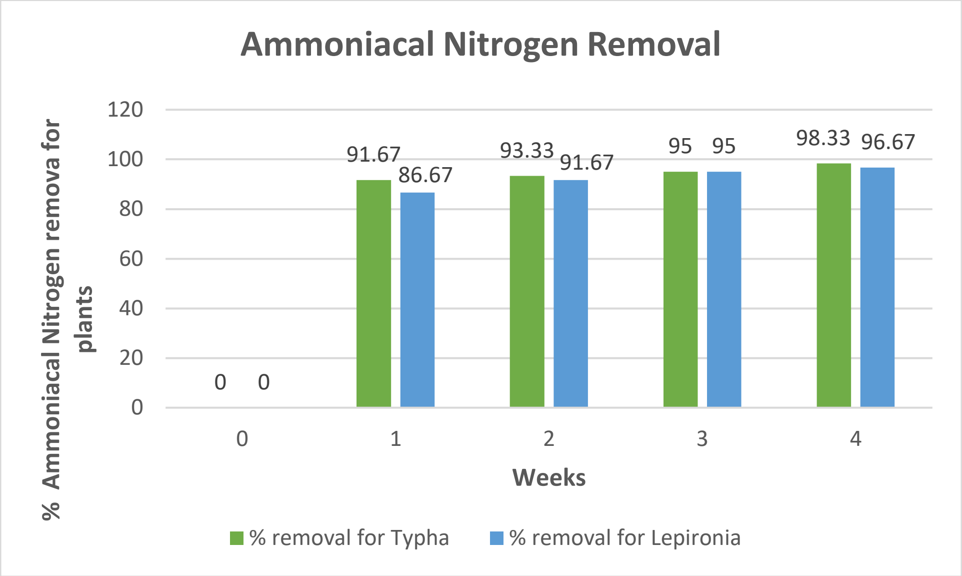


Figure 4. 11 The result of percent Ammoniacal Nitrogen removal

According to the figure 4.10, the amount of ammoniacal nitrogen has decreased from the lake water's influent to the Phyto green area. This is due to the fact that the water from the influent is still untreated, and when the water runs through the plant, the plant adsorbs and absorbs the ammoniacal nitrogen as a source of food. The amount of ammoniacal nitrogen will decrease over time as a result of this process from 0.6 mg/l to 0.1 mg/L and 0.2 mg/l for *Typha Angustifolia* and *Lepironia Articulata*. It will result the decreasing class of water from class II to class I. At week 4 as shown in figure 4.11, the removal of ammoniacal nitrogen was 98.33% for *Typha Angustifolia* plants and 96.67% for *Lepironia Articulata* plants. It has shown that these two aquatic plants have the high potential to remove the ammoniacal nitrogen contaminants from the water.

4.2.8 Aluminium (AI3+)

The Aluminium of the KotaSAS Lake Water was measured and recorded from the beginning of the study.

Table 4. 8 Result of Aluminium (mg/L)

Week	*Typha Angustifolia*	*Lepironia Articulata*
1.	0.176	0.176

Week	*Typha Angustifolia*	*Lepironia Articulata*
2.	0.103	0.142
3.	0.073	0.091
4.	0.055	0.064
5.	0.034	0.048

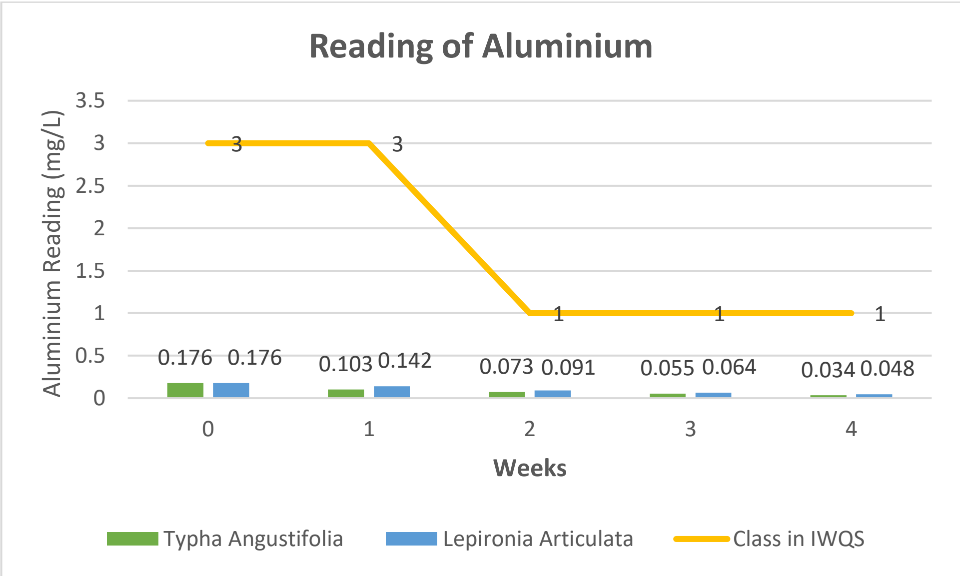


Figure 4. 12 The result of Aluminium test

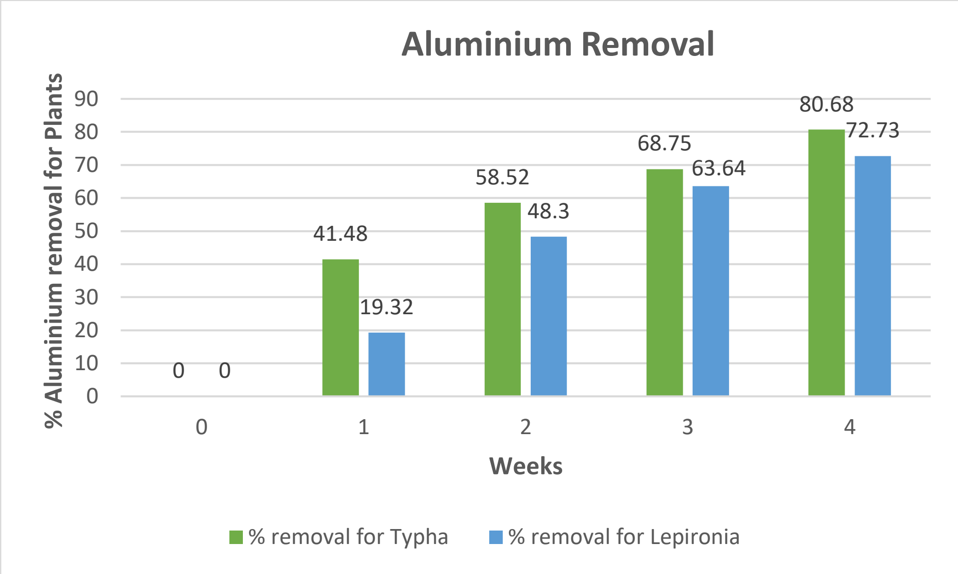


Figure 4. 13 The result of percent Aluminium removal

According to the graph in figure 4.12, the reading of aluminium decreases along the graph in 4 weeks with the initial is 0.176 mg/L to 0.034 mg/L using *Typha Angustifolia* and 0.048 m/L using *Lepironia Articulata*. This is because the rhizofiltration method uses the roots of plants to remove a variety of pollutants. The elimination of aluminium with this procedure may raise the class from III to I. Based on figure 4.13, we may conclude that using *Typha Angustifolia* plants (80.68%) are more effective to remove the number of aluminium compare to the *Lepironia Articulata* plants (72.73%)

4.2.9 Manganese (Mn)

The Manganese of the KotaSAS Lake Water was measured and recorded from the beginning of the study.

Table 4. 9 Result of Manganese (mg/L)

Week	*Typha Angustifolia*	*Lepironia Articulata*
1.	1.8	1.8

Week	*Typha Angustifolia*	*Lepironia Articulata*
2.	1.2	1.0
3.	0.5	0.4
4.	0.3	0.3
5.	0.2	0.2

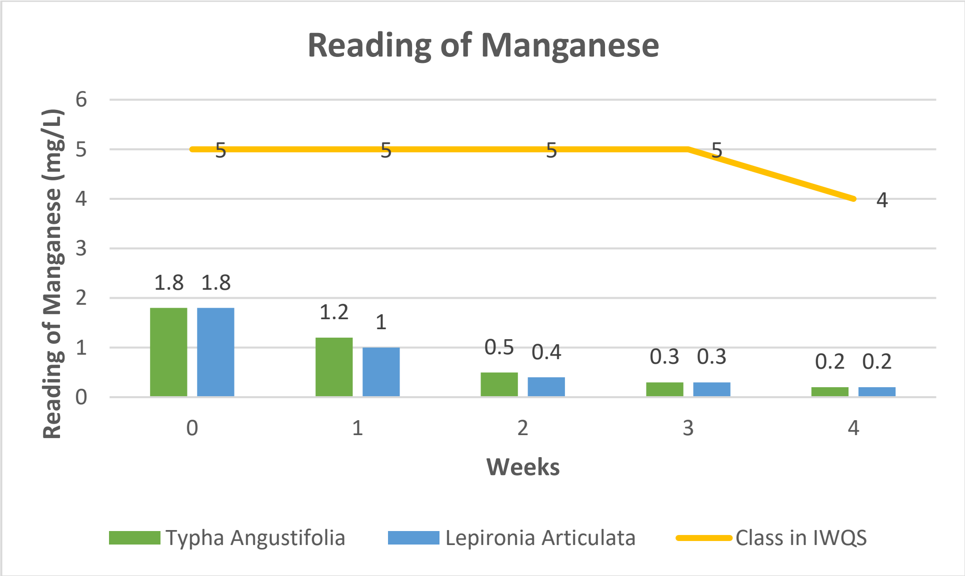


Figure 4. 14 The result of Manganese test

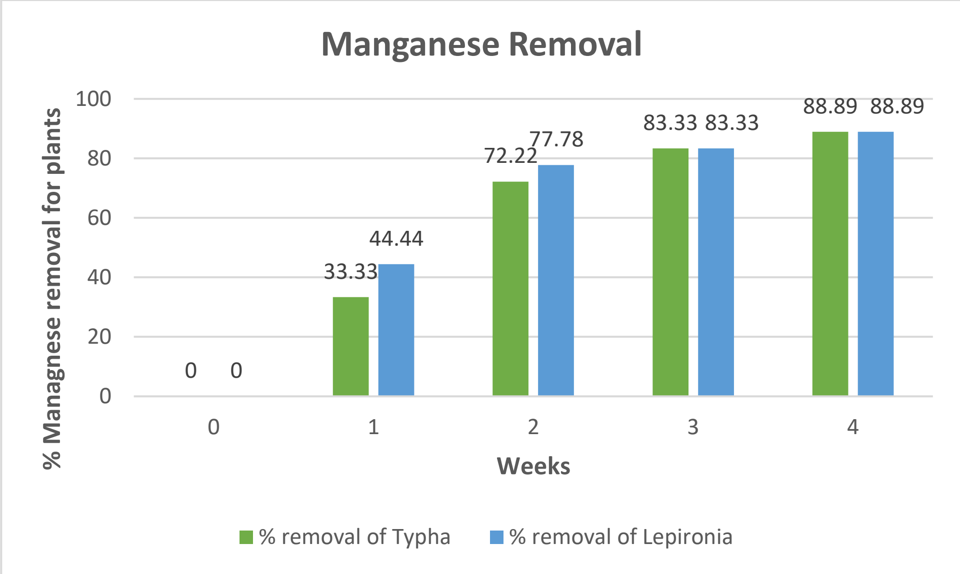


Figure 4. 15 The result of percent Manganese removal

Manganese is found naturally in groundwater, but levels can be increased by human activities like laundry, steel production and mining. The higher quantities of manganese can turn the water to a brown or rust color. Based on figure 4.14, it was shows that the amount of manganese at the initial was higher compare to other water parameter which is 1.8 mg/L at Class 5 in IWQS. Which means that this water cannot be used. But, after using rhizofiltration process, the number of manganese was slowly decrease to 0.2 mg/L in class 4 in week 4. Based on figure 4.15, it shows that the percent of removal using these two types of plants are equally which is 88.89% in week 4.

4.2.10 Iron (Fe)

The Iron of the KotaSAS Lake Water was measured and recorded from the beginning of the study.

Table 4. 10 Result of Iron (mg/L)

Week	*Typha Angustifolia*	*Lepironia Articulata*
1.	1.22	1.22

Week	*Typha Angustifolia*	*Lepironia Articulata*
2.	1.04	1.07
3.	0.22	0.51
4.	0.13	0.30
5.	0.11	0.19

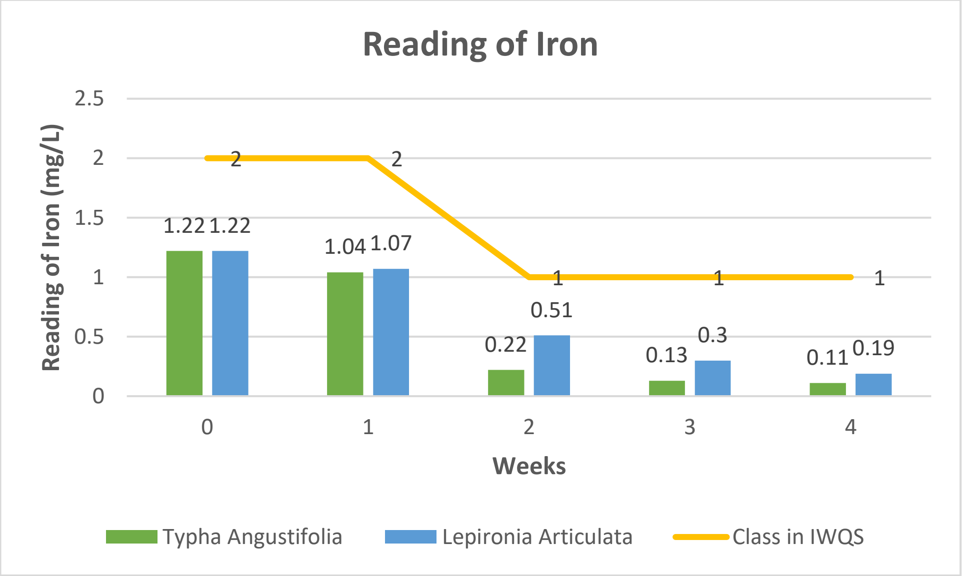


Figure 4. 16 The result of percent Iron removal

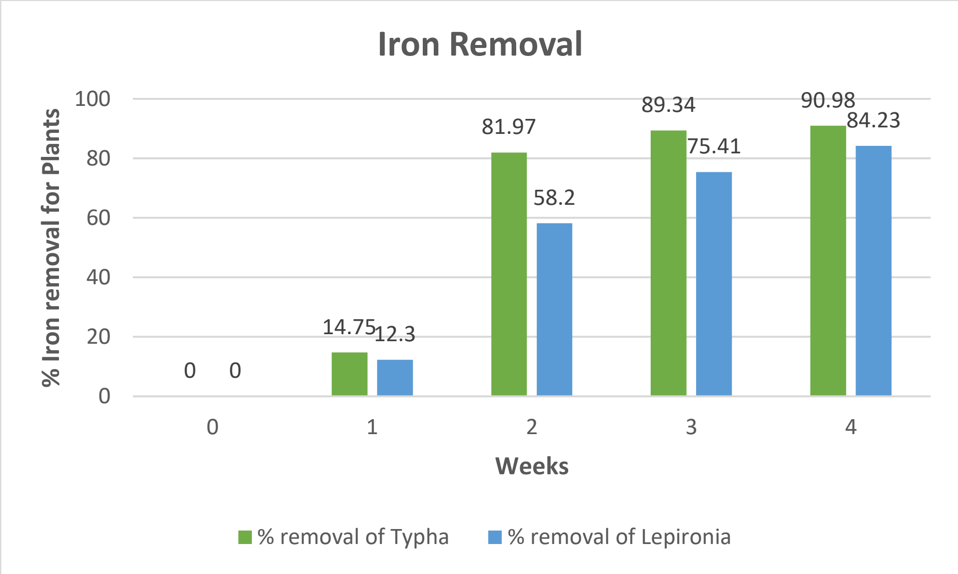


Figure 4. 17 The result of percent Iron removal

According to Van Donck (2015) mention that the level iron compound is the higher in lake due to the naturally found in high quantities in lake sediments. So, this is why iron testing has been conducted. The efficacy of removing iron reached 90.98% for *Typha Angustifolia* plants and 84.23% for *Lepironia Articulata* plants, according to the percentage removal graph in figure 4.16. Compare with this type of plants that has been used, *Typha Angustifolia* are more effective to removes iron components in KotaSAS Lake. As a result of this process, the amount of iron will decrease over time in 4 weeks from 1.22 mg/L to 0.11mg/L using *Typha Angustifolia* and 0.19 mg/L *Lepironia Articulata* as shows in figure 4.17. Reduced iron levels in lake water can assist to enhance water quality and make it safer to release.

CHAPTER 5

CONCLUSION

5.1 Introduction

It has been proven that phytoremediation of wastewater treatment utilising a floating plant system is a popular technology that is cheap to install, requires low maintenance, and enhances biodiversity. Climate, pollutant concentrations, temperature, and other variables all influence their treatment capability. Total Suspended Solids, Biochemical Oxygen Demand, Chemical Oxygen Demand, Dissolved Oxygen, Ammoniacal Nitrogen, and Heavy Metals pollutant removal efficacy vary per plant.

5.2 Conclusion

The conclusions reached are typically bound by the objectives and scope of investigation established in chapter one. Therefore, we may conclude that:

i. The current study demonstrated that *Lepironia Articulata* and *Typha Angustifolia* are suitable aquatic plants for wastewater treatment via phytoremediation. These two plants have the capacity to accumulate contaminants and heavy metals.

ii. The percentage removal of organic and heavy metal pollutants in wastewater has also been proven to be successful. For BOD parameter, Typha Angustifolia has the highest percent of removal with 50% compare to Lepironia Articulata with 36.36%. As for COD, Typha Angustifolia also has the highest percent which is 92.31% and Lepironia Articulata 91.54%. Next, the percent removal of TSS and Ammoniacal Nitrogen also increases in week 1 until week 4 after using rhizofiltration process. The final week reach until more than 90% using these two types of plant. Then, using this process has shown that the amount of Aluminium, Manganese and Iron may be decrease every week. But Manganese will take more time to remove heavy metals using these two plants compare to aluminium and iron. And, we can see from the reading in table 4.8,4.9 and 4.10, *Typha Angustifolia* are more effectives to removes heavy metals compare to *Lepironia Articulata*.

iii. According to the experiment findings, the plants are still alive and green at the end of the experiment. It was convincingly demonstrated that all of the plants utilised can survive in wastewater. These plants are be able to thrive and withstand wastewater in order to be used for phytoremediation.

5.3 Recommendation

The two plants were examined for phytoremediation for the removal of organic and heavy metals matter in this study. However, in order to fully harness these potential outcomes in the field of phytoremediation, additional research needs be conducted on plant genetic components. After executing the experiment and collecting the findings, a few ideas for resolving the problem and acquiring more accurate data for this project were developed. These following recommendations will help to maintain and develop phytoremediation processes for future research:

i. More comprehensive field study over longer time periods are needed to have a better understanding of the possible involvement of phytoremediation.

ii. Regular monitoring should be implemented, and monitoring should be carried out by professionals in collaboration with ecologies. Monitoring and assessment have been used to develop environmental protection strategies.

iii. Use high-efficiency equipment, technology, or devices that generate minimal or no waste. Furthermore, we may modify existing equipment to boost recovery choices, restructure operating lines, and maintain and improve operational efficiency.

REFERENCES

Alex Alexandrov, N., & Alexandrov, V. (2015). Computational science research methods for science Ali, H., Khan, E., & Ilahi, I. (2019). Environmental Chemistry And Ecotoxicology Of Hazardous Heavy Metals: Environmental Persistence, Toxicity, And Bioaccumulation. *Journal Of Chemistry*, *2019*, 1–14. Https://Doi.Org/10.1155/2019/6730305

Aljerf, L. (2018). Advanced highly polluted rainwater treatment process. *Journal of Urban and Environmental Engineering*, *12*(1), 50–58. https://doi.org/10.4090/juee.2018.v12n1.050058

Ashraf, S., Ali, Q., Zahir, Z. A., Ashraf, S., & Asghar, H. N. (2019). Phytoremediation: Environmentally Sustainable Way For Reclamation Of Heavy Metal Polluted Soils. *Ecotoxicology And Environmental Safety*, *174*, 714–727. Https://Doi.Org/10.1016/J.Ecoenv.2019.02.068

Chaudhry, H., Nisar, N., Mehmood, S., Iqbal, M., Nazir, A., & Yasir, M. (2020). Indian mustard brassica juncea efficiency for the accumulation, tolerance and translocation of zinc from metal contaminated soil. *Biocatalysis and Agricultural Biotechnology*, *23*, 101489. https://doi.org/10.1016/j.bcab.2019.101489

Chaudhry, H., Nisar, N., Mehmood, S., Iqbal, M., Nazir, A., & Yasir, M. (2020). Indian mustard brassica juncea efficiency for the accumulation, tolerance and translocation of zinc from metal contaminated soil. *Biocatalysis and Agricultural Biotechnology*, *23*, 101489. https://doi.org/10.1016/j.bcab.2019.101489

Crapnell, R. D., & Banks, C. E. (2022). Electroanalytical Overview: The determination of manganese. *Sensors and Actuators Reports*, *4*, 100110. https://doi.org/10.1016/j.snr.2022.100110

Dhaliwal, S. S., Singh, J., Taneja, P. K., & Mandal, A. (2019). Remediation Techniques For Removal Of Heavy Metals From The Soil Contaminated Through Different Sources: A Review. *Environmental Science And Pollution Research*, *27*(2), 1319–1333. Https://Doi.Org/10.1007/S11356-019-06967-1

Hassan Omer, N. (2020). Water quality parameters. *Water Quality - Science, Assessments and Policy*. https://doi.org/10.5772/intechopen.89657

Jacob, J. M., Karthik, C., Saratale, R. G., Kumar, S. S., Prabakar, D., Kadirvelu, K., & Pugazhendhi, A. (2018). Biological Approaches To Tackle Heavy Metal Pollution: A Survey Of Literature. *Journal Of Environmental Management*, *217*, 56–70. Https://Doi.Org/10.1016/J.Jenvman.2018.03.077

Kurniawan, S., Purwanti, I., & Titah, H. (2018). The effect of ph and aluminium to bacteria isolated from aluminium recycling industry. *Journal of Ecological Engineering*, *19*(3), 154–161. https://doi.org/10.12911/22998993/86147

Li, L., He, Y., Song, K., Xie, F., Li, H., & Sun, F. (2021). Derivation of water quality criteria of zinc to protect aquatic life in Taihu Lake and the associated risk assessment. *Journal of Environmental Management*, *296*, 113175.

https://doi.org/10.1016/j.jenvman.2021.113175

Muthusaravanan, S., Sivarajasekar, N., Vivek, J. S., Paramasivan, T., Naushad, M., Prakashmaran, J., Gayathri, V., & Al-Duaij, O. K. (2018). Phytoremediation of heavy metals: Mechanisms, methods and enhancements. *Environmental Chemistry Letters*, *16*(4), 1339–1359. https://doi.org/10.1007/s10311-018-0762-3

Ozturk, M., Metin, M., Altay, V., De Filippis, L., Ünal, B. T., Khursheed, A., Gul, A., Hasanuzzaman, M., Nahar, K., Kawano, T., & Caparrós, P. G. (2021). Molecular Biology Of Cadmium Toxicity In Saccharomyces Cerevisiae. *Biological Trace Element Research*, *199*(12), 4832–4846. Https://Doi.Org/10.1007/S12011-021-02584-7

Parveen, A., Saleem, M. H., Kamran, M., Haider, M. Z., Chen, J.-T., Malik, Z., Rana, M. S., Hassan, A., Hur, G., Javed, M. T., & Azeem, M. (2020). Effect Of Citric Acid On Growth, Ecophysiology, Chloroplast Ultrastructure, And Phytoremediation Potential Of Jute (Corchorus Capsularis L.) Seedlings Exposed To Copper Stress. *Biomolecules*, *10*(4), 592. Https://Doi.Org/10.3390/Biom10040592

Rahman, Z., & Singh, V. P. (2019). The Relative Impact Of Toxic Heavy Metals (Thms) (Arsenic (As), Cadmium (CD), Chromium (CR)(VI), Mercury (Hg), And Lead (PB)) On The Total Environment: An Overview. *Environmental Monitoring And Assessment*, *191*(7). Https://Doi.Org/10.1007/S10661-019-7528-7 c

Sander, S., Kappenstein, O., Ebner, I., Fritsch, K.-A., Schmidt, R., Pfaff, K., & Luch, A. (2018). Release of aluminium and thallium ions from uncoated food contact materials made of aluminium alloys into food and food simulant. PLOS ONE, 13(7). https://doi.org/10.1371/journal.pone.0200778

Titah, H. S., Purwanti, I. F., Tangahu, B. V., Kurniawan, S. B., Imron, M. F., Abdullah, S. R., & Ismail, N. ‘I. (2019). Kinetics of aluminium removal by locally isolated Brochothrix thermosphacta and vibrio alginolyticus. *Journal of Environmental Management*, *238*, 194–200. https://doi.org/10.1016/j.jenvman.2019.03.011

Wang, Y., Tan, S. N., Mohd Yusof, M. L., Ghosh, S., & Lam, Y. M. (2022). Assessment Of Heavy Metal And Metalloid Levels And Screening Potential Of Tropical Plant Species For Phytoremediation In Singapore. *Environmental Pollution*, *295*, 118681. Https://Doi.Org/10.1016/J.Envpol.2021.118681

Wei, Z., Van Le, Q., Peng, W., Yang, Y., Yang, H., Gu, H., Lam, S. S., & Sonne, C. (2021). A Review On Phytoremediation Of Contaminants In Air, Water And Soil. *Journal Of Hazardous Materials*, *403*, 123658. Https://Doi.Org/10.1016/J.Jhazmat.2020.123658

Yan, Y.-Y., Yang, B., Lan, X.-Y., Li, X.-Y., & Xu, F.-L. (2019). Cadmium Accumulation Capacity And Resistance Strategies Of A Cadmium-Hypertolerant Fern — Microsorum Fortunei. *Science Of The Total Environment*, *649*, 1209–1223. Https://Doi.Org/10.1016/J.Scitotenv.2018.08.281

APPENDICES

Appendix 1: National Water Quality Standard of Malaysia

ANNEX

NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA

PARAMETER	UNIT	CLASS				
		I	IIA/IIB	III#	IV	V
Al	mg/l	NATURAL LEVELS OR ABSENT	-	(0.06)	0.5	LEVELS ABOVE IV
As	mg/l		0.05	0.4 (0.05)	0.1	
Ba	mg/l		1	-	-	
Cd	mg/l		0.01	0.01* (0.001)	0.01	
Cr (VI)	mg/l		0.05	1.4 (0.05)	0.1	
Cr (III)	mg/l		-	2.5	-	
Cu	mg/l		0.02	-	0.2	
Hardness	mg/l		250	-	-	
Ca	mg/l		-	-	-	
Mg	mg/l		-	-	-	
Na	mg/l		-	-	3 SAR	
K	mg/l		-	-	-	
Fe	mg/l		1	1	1 (Leaf) 5 (Others)	
Pb	mg/l		0.05	0.02* (0.01)	5	
Mn	mg/l		0.1	0.1	0.2	
Hg	mg/l		0.001	0.004 (0.0001)	0.002	
Ni	mg/l		0.05	0.9*	0.2	
Se	mg/l		0.01	0.25 (0.04)	0.02	
Ag	mg/l		0.05	0.0002	-	
Sn	mg/l		-	0.004	-	
U	mg/l		-	-	-	
Zn	mg/l		5	0.4*	2	
B	mg/l		1	(3.4)	0.8	
Cl	mg/l		200	-	80	
Cl_2	mg/l		-	(0.02)	-	
CN	mg/l		0.02	0.06 (0.02)	-	
F	mg/l		1.5	10	1	
NO_2	mg/l		0.4	0.4 (0.03)	-	
NO_3	mg/l		7	-	5	
P	mg/l		0.2	0.1	-	
Silica	mg/l		50	-	-	
SO_4	mg/l		250	-	-	
S	mg/l		0.05	(0.001)	-	
CO_2	mg/l		-	-	-	
Gross-α	Bq/l		0.1	-	-	
Gross-β	Bq/l		1	-	-	
Ra-226	Bq/l		< 0.1	-	-	
Sr-90	Bq/l		< 1	-	-	
CCE	µg/l		500	-	-	-
MBAS/BAS	µg/l		500	5000 (200)	-	-
O & G (Mineral)	µg/l		40; N	N	-	-
O & G (Emulsified Edible)	µg/l		7000; N	N	-	-
PCB	µg/l		0.1	6 (0.05)	-	-
Phenol	µg/l		10	-	-	-
Aldrin/Dieldrin	µg/l		0.02	0.2 (0.01)	-	-
BHC	µg/l		2	9 (0.1)	-	-
Chlordane	µg/l		0.08	2 (0.02)	-	-
t-DDT	µg/l		0.1	(1)	-	-
Endosulfan	µg/l		10	-	-	-
Heptachlor/Epoxide	µg/l		0.05	0.9 (0.06)	-	-
Lindane	µg/l		2	3 (0.4)	-	-
2,4-D	µg/l		70	450	-	-
2,4,5-T	µg/l		10	160	-	-
2,4,5-TP	µg/l		4	850	-	-
Paraquat	µg/l		10	1800	-	-

Notes :
* = At hardness 50 mg/l $CaCO_3$
\# = Maximum (unbracketed) and 24-hour average (bracketed) concentrations
N = Free from visible film sheen, discolouration and deposits

NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA (cont.)

PARAMETER	UNIT	CLASS					
		I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	> 2.7
Biochemical Oxygen Demand	mg/l	1	3	3	6	12	> 12
Chemical Oxygen Demand	mg/l	10	25	25	50	100	> 100
Dissolved Oxygen	mg/l	7	5 - 7	5 - 7	3 - 5	< 3	< 1
pH	-	6.5 - 8.5	6 - 9	6 - 9	5 - 9	5 - 9	-
Colour	TCU	15	150	150	-	-	-
Electrical Conductivity*	μS/cm	1000	1000	-	-	6000	-
Floatables	-	N	N	N	-	-	-
Odour	-	N	N	N	-	-	-
Salinity	ppt	0.5	1	-	-	2	-
Taste	-	N	N	N	-	-	-
Total Dissolved Solid	mg/l	500	1000	-	-	4000	-
Total Suspended Solid	mg/l	25	50	50	150	300	300
Temperature	°C	-	Normal + 2 °C	-	Normal + 2 °C	-	-
Turbidity	NTU	5	50	50	-	-	-
Faecal Coliform**	count/100 ml	10	100	400	5000 (20000)[a]	5000 (20000)[a]	-
Total Coliform	count/100 ml	100	5000	5000	50000	50000	> 50000

Notes :

N : No visible floatable materials or debris, no objectional odour or no objectional taste
* : Related parameters, only one recommended for use
** : Geometric mean
a : Maximum not to be exceeded

WATER CLASSES AND USES

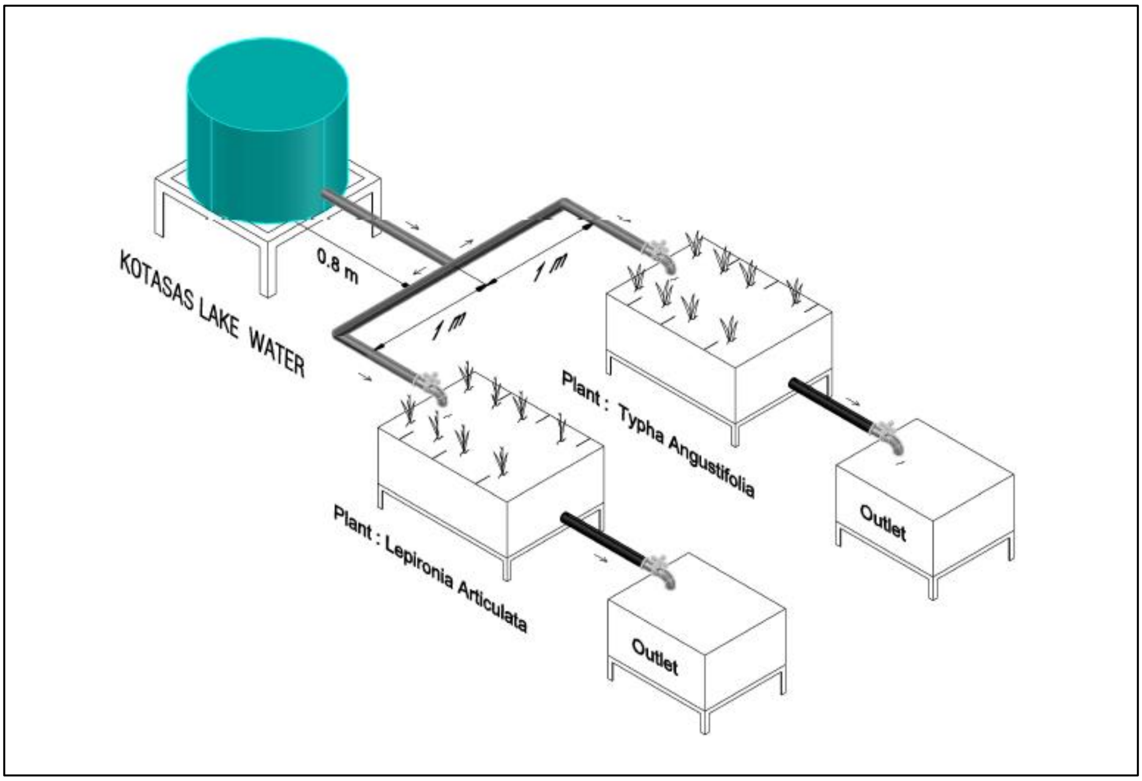
CLASS	USES
Class I	Conservation of natural environment. Water Supply I – Practically no treatment necessary. Fishery I – Very sensitive aquatic species.
Class IIA	Water Supply II – Conventional treatment required. Fishery II – Sensitive aquatic species.
Class IIB	Recreational use with body contact.
Class III	Water Supply III – Extensive treatment required. Fishery III – Common, of economic value and tolerant species; livestock drinking.
Class IV	Irrigation
Class V	None of the above.

Appendix 2: Collection of Typha Angustifolia plants

Appendix 3: Collection of Lepironia Articulata plants

Appendix 4: Collection of KotaSAS Lake water

Appendix 5: Preparation of water flow in aquarium



Appendix 6: Removal Efficiency Formula

$$\% \text{ Removal Efficiency} = \frac{Influent\left(\frac{mg}{L}\right) - Effluent\left(\frac{mg}{L}\right)}{Influent\left(\frac{mg}{L}\right)} \text{ X } 100\%$$

Appendix 7: Water Parameter Testing