EFFECTIVENESS OF WATER HYACINTH (*EICHHORNIA CRASSIPES*) IN TREATMENT OF WASTEWATER AT GEBENG INDUSTRIAL AREA

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ABSTRAK

Pencemaran air merupakan isu yang serius pada masa ini terutamanya sungai, tasik atau kolam berhampiran kawasan perindustrian. Ini adalah kerana air buangan dari industri yang dibuang ke dalamnya selepas beberapa rawatan. Senario ini berbahaya kepada manusia, tetapi juga kepada alam sekitar terutama untuk kehidupan akuatik termasuk tumbuh-tumbuhan dan haiwan. Phytoremediation adalah salah satu alternatif bio-hijau yang boleh merawat air tercemar dengan berkesan. Mekanisme proses ini menggunakan tumbuhan akuatik di mana tumbuhan ini menyerap bahan pencemar dari air dan air menjadi bersih tanpa membahayakan tumbuhan ini. Gondok air (eichhornia crassipes) adalah salah satu tumbuhan akuatik yang menjalani proses phytoremediation secara berkesan termasuk dalam mengeluarkan logam berat seperti plumbum, kadmium dan zink. Kajian ini adalah untuk menentukan keberkesanan air gondok (eichhornia crassipes) dalam rawatan air kumbahan berhampiran perindustrian. Kajian ini dijalankan selama 3 minggu. Kepekatan air sisa adalah 50%, 75% dan 100%. Dari kajian ini, kecekapan penyingkiran tertinggi dalam peratusan selepas 3 minggu untuk BOD (mg / l) adalah 35.78%, COD (mg / l) adalah 62.50%, pH adalah 38.57%, TSS (mg / l) adalah 50%, NH3-N (mg / l) ialah 84.91%, kekeruhan (NTU) adalah 42.34%, Plumbum (mg / l) adalah 70.27%, Kadmium (mg / l) adalah 77.27%, Zinc (mg/l) adalah 83.64%. Walaupun, untuk meningkatkan penyingkiran dalam peratus selepas 3 minggu oksigen terlarut (mg / l) ialah 41.52%. Kecekapan penyingkiran bahan pencemar untuk rawatan lebih berkesan untuk air kumbahan pada kepekatan 50% air kumbahan berbanding 75% dan 100%.

ABSTRACT

Water pollution is a serious issues nowadays especially rivers, lake or pond near the industrial area. This is because of the wastewaters from industry are discharge into it after a few treatments. This scenario is dangerous and harmful to human, but also to environment especially for aquatic life including plants and animals. Phytoremediation is one of bio-green alternatives that can treat polluted water effectively. Mechanism of this process is using aquatic plants where these plants absorb the contaminant from the water and the water become clean without giving harmful to these plants. Water hyacinth (*eichhornia crassipes*) is one of the aquatic plants that undergo phytoremediation process effectively including in removing of heavy metal such as plumbum, cadmium and zinc. This study is to determine the effectiveness of water hyacinth (*eichhornia crassipes*) in treatment of wastewater near industrial. This study was conducted for 3 weeks. The concentrations of wastewater were 50%, 75% and 100%. From this research, the highest removal efficiency in percentage after 3 weeks for BOD (mg/l) was 35.78%, COD (mg/l) was 62.50%, pH was 38.57%, TSS (mg/l) was 50%, NH3-N (mg/l) was 84.91%, turbidity (NTU) was 42.34%, Plumbum (mg/l) is 70.27%, Cadmium (mg/l) was 77.27%, Zinc (mg/l) was 83.64%. While, for increasing removal in percentage after 3 weeks for dissolved oxygen (mg/l) was 41.52%. The removal efficiency of pollutants for treatment was more effective for wastewater at 50% concentration of wastewater compared 75% and 100%.

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LIST OF SYMBOLS

˚c	Degree Celcius
%	Percentage
mg/l	Miligram per litre
L	Litre

LIST OF ABBREVIATIONS

DO	Dissolved Oxygen
NTU	Nephelometric Turbidity Units
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
TSS	Total Suspended Solid
NH_3-N	Ammoniacal Nitrogen
Pb	Plumbum
Cd	Cadmium
Zn	Zinc

CHAPTER 1

INTRODUCTION

1.1 Introduction

Water hyacinth (*Eichhornia Crassipes*) is one of the aquatic plants that grow in water and floating without anchorage. As we know, water hyacinth is plants that grow rapidly without proper care on the lakes or ponds. This plant is one of the kinds of plant that grow by it. Even though, water hyacinth present only considered as a worst aquatic weed which can destroy native habitats and effect rates of transpiration, but water hyacinth has bioremediation or phytoremediation property hence has been used for the removal or reduction of nutrient pollutants, heavy metals, organic compounds and pathogens from water (Gopal, 1987).

The plant roots naturally absorb pollutants, including toxic chemicals such as lead and mercury, as well as some organic compounds if the plant was put at industrial wastewater. Industrial wastewater is wastewater that discharged from industrial to the rivers or streams. Type of contaminants and pollutants that are discharge is depends on the type of industrial. This can be affected to the rivers itself which the quality of the water would decrease. As we know, water is essential to all living things including when involved in the human's activities. That's why, a biotechnology way have been introduced to treat this problem. One of it is by using phytoremediation process.

Phytoremediation is the use of plants and associated microorganisms to immobilize (phytostabilization), remove (phytoextraction), evaporate (phytoporation), or degrade (phytodegradation, rhizodegradation) pollutants from soil and environment (A. Placek et al., 2016). As we know, plants act as filters or traps which can break down or degrade organic pollutants or contain and stabilize metal contaminants. For this process to occur, growing plants has to be put in a contaminated matrix for a required growth period to remove contaminants from the matrix or degradation of the pollutants. At the end, those plants can be subsequently harvested, processed and disposed of in an environmentally proper ways. To sum it up, phytoremediation in aquatic media is directly up take and accumulation of contaminant from water media and assimilation by plants (Ndimele and Ndimele, 2013).

1.2 Problem Statement

Industries are the major sources of pollutions in all environments specifically on water. River systems are the main way for disposal of wastes, especially the wastewater from factories, from industries that are near them. Various levels of pollutants were discharged into the environment according to the type of the industry directly or indirectly through public sewer lines. The common one is wastewater from industries. This wastewater from industries includes employees' sanitary waste, process wastes from manufacturing, wash waters and relatively uncontaminated water from heating and cooling operations. As a consequence, high levels of pollutants in river water systems causes an increase in biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS) and heavy metals, hence make the water unsuitable for drinking, irrigation and aquatic life.

This situation can lead water pollution. As we know, water pollution is a serious problem that we are facing now. This phenomenon has become a global issue. This is because; water is a very essential thing to human mankind including other living organism. In addition of World Water Day 2003, the United Nation Conferences and Development warning that two billions of earth population will die because of water. Furthermore, earth population will experience water shortage by year 2025, if the usage of water is the same rate as today. It is 10 times higher than the death because of war (UNCED, 2003). That's why; phytoremediation was introduced as an alternative way to treat the wastewater.

1.3 Objectives

The objectives of this research are :

i) To determine the pollution status of wastewater at Gebeng Industrial area

ii) To investigate the pollution reduction efficiency of water hyacinth (*eichhornia crassipes*) for removal of pollutant from wastewater.

1.4 Scope of study

Scope of study was determined according to the factor causes of the problem and method of treating the polluted water from any contaminants by using the new alternative and innovative known as phytoremediation. The scope that has been determined is used to aim and potential to achieve the objectives/target of the research.

The scopes of the study are following:

I. Phytoremediation method that using in pollution the wastewater should be doing perform. Thus, the wastewater will be taken from hole that the wastes discharge from factory at industrial area, Gebeng.

II. Experiment will be doing at the experimental laboratory to measure the parameters of the wastewater such as biochemical oxygen demand, chemical oxygen demand, dissolved oxygen, pH value, turbidity, total suspended solid, and heavy metals.

III. The plant has been recognized that using in the phytoremediation method is *eichhornia crassipes*.

1.5 Significance of Research

From this research, there are many benefits that we can obtain by conducting the phytoremediation process in treating the contaminant in the industrial wastewater. This is because, using this process, it can save the cost of wastewater treatment because it just using the water-based plants that living at the swamp without using the money or costly chemical. It is a technology that using plants. Phytoremediation is the technology which uses plants and rhizospheric microorganisms to remove pollutants in soil, sediment, groundwater, surface water and even chemical pollutants in atmosphere. (T. Kösesakal et al.,2016).

The scientific studies and relevant development of those plants' abilities had only been conducted since the early 1980's (A.M. Paz-Alberto et al.,2013). But still, it is important to do further investigation in plants living especially aquatic plants that potentially solve the wastewater problems and sustain the water quality. Furthermore, by using this method, water pollution can be reduced and overcome plus water quality can be improved by using the easier way.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides a review of industry wastewater and the treatment method of industry wastewater by phytoremediation mechanism using *eichhornia crassipes.* This chapter also provides details information that related to the research studies. Besides, the parameters such as COD, BOD, DO, turbidity, TSS, pH, temperature and heavy metals also were explain in this chapter. The heavy metals are Plumbum (Pb), Cadmium (Cd), and Zinc (Zn). Furthermore, the detailed about water hyacinth (*eichhornia crassipes)* and phytoremediation have been reviewed in this chapter.

2.2 Industry Wastewater

Industrial area is an area designed and zoned for manufacturing and associated businesses and activities. Since, each factory is manufacturing their products, so there are waste materials from manufacturing that. The waste can be in liquid state since it's easily discharge to outside especially to rivers nearby after a few of treatments. Gebeng, Industrial Estate houses a world-class chemical and petrochemical industrial zone.

Wastewaters from chemical industry are generally strong and may contain toxic pollutants. These wastewaters usually has strong colour, odour and contains large amounts of hazardous, toxic organic compounds and high concentration of salts. Besides, organic and inorganic matter in varying degrees of concentration also usually contain by the wastewaters. It contains acids, bases, toxic materials, and matters that are high in biological oxygen demand and low in suspended solids. Many materials in this industry are toxic, mutagenic, carcinogenic or simply hardly biodegradable, so, of course, its waste also may contain these types of characteristics. In chemical industry, the high variability, stringent effluent permits, and extreme operating conditions define the practice of wastewater treatment (Bury et al., 2002). So, phytoremediation process was selected for the treatment of these wastewaters. Figure 2.1 shows how condition river nearby industry area while table 2.1 shows substances present in industrial effluents (Bond & Straub, 1974).

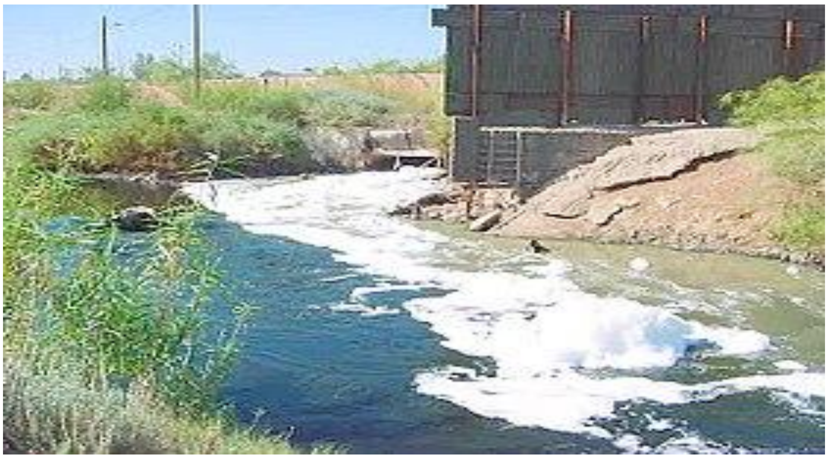

Figure 2.1 River nearby industry area

2.3 Parameters for Phytoremediation Process

There are 9 parameters that were done in this study which to undergo phytoremediation process which are dissolved oxygen, temperature, pH value, turbidity, BOD, COD, TSS, ammoniacal nitrogen and heavy metals. Heavy metals that were done are cadmium, plumbum and zinc.

2.3.1 DO

The dissolved oxygen (DO) level can be an indication of how polluted the water is and how well the water can support aquatic plant and animal life. DO is essential to healthy streams and lakes. Generally, a higher dissolved oxygen level indicates better water quality. If dissolved oxygen levels are too low, some fish and other organisms may not be able to survive. Much of the dissolved oxygen in water comes from oxygen in the air that has dissolved in the water. Some of the dissolved oxygen in the water is a result of photosynthesis of aquatic plants.

On sunny days, high DO levels occur in areas of dense algae or plants due to photosynthesis. Stream turbulence may also increase DO levels because air is trapped under rapidly moving water and the oxygen from the air will dissolve in the water. Water temperature also affects DO levels. Colder water can hold more oxygen in it than warmer water.

2.3.2 Temperature

Temperature is currently defined by the "International Practical Temperature Scale of 1968, amended edition 1975" in terms of the electrical resistance of a standard platinum- resistance thermometer at three calibration points (the triple point of water, the boiling point of water at one standard atmosphere and the freezing point of zinc). Measurement for water treatment purposes may be made with any good-grade mercury-filled Celsius thermometer. As a minimum requirement, the thermometer should have a scale marked for every 0.1°C and should be checked against a thermometer certified by the U.S. National Bureau of Standards. A thermistor may also be used, although higher cost may preclude its widespread use. Thermistors used in some large water treatment plants for continuous temperature monitoring are calibrated using the melting point of water as a standard.

The temperature dependence of most chemical reactions stems from the activation energy associated with them. In general, the rates of chemical reactions decrease with decreasing temperature. The relative concentrations of reactants and products in chemical equilibria can also change with temperature. The magnitude of this change basically depends on the Gibbs free energy change of the reaction in question. Temperature can therefore affect every aspect of the treatment and the delivery of potable water.

2.3.3 pH value

The pH refers to the hydrogen ion concentration or how acidic or basic as water is and pH is defined as $-\log[H+]$. pH value range from 0-14; pH 7 is neutral, $pH<7$ is acidic and $pH>7$ is basic. pH is a measure of the relative amount of free hydrogen and hydroxyl ions in the water. Water that has more free hydrogen ions is acidic, whereas water that has more free hydroxyl ions is basic. Since pH can be affected by chemicals in the water, pH is an important indicator of water that is changing chemically. The pH of water determines the solubility which means the amount that can be dissolved in the water and biological availability which are amount that can be utilized by aquatic life of chemical constituents such as nutrients such as phosphorus, nitrogen and carbon and heavy metals such as lead, copper, cadmium etc.

In case of heavy metals, the degree to which they are soluble determines their toxicity. Metals tend to be more toxic at lower pH because they are more soluble. pH is most important in determining the corrosive nature of water. Lower the pH value higher is the corrosive nature of water. pH was positively correlated with electrical conductance and total alkalinity. The reduced rate of photosynthetic activity, the assimilation of carbon dioxide and bicarbonates which are ultimately responsible for increase in pH, the low oxygen values coincided with high temperature during the summer month. The higher pH values observed suggests that carbon dioxide, carbonate-bicarbonate equilibrium is affected more due to change in physicochemical condition (K. R. Karanth, 1987). Furthermore, pH value greater than 9.5 or very low which is lower than 4.5 values are unsuitable for most aquatic organisms. Aquatic organisms are extremely sensitive to pH levels below 5 and may die at these low pH values. High pH levels which in range 9-14 can harm fish due to the fact that ammonia will turn to toxic ammonia at high pH which is more than 9. (Manoj Kumar et al., 2014)

The pH for drinking water generally lies between 6.5 and 8.0 at 25°C (80° F). The pH of the water in a stream, river, lake or underground flow will vary depending on a source of the water, type of soil, bedrock, types of contaminants the water encounters in its path. The effects of a specific type of water pollution on living plants and animals can vary greatly. No health-based guideline value is proposed for pH by the WHO. Although pH usually has no direct impact on consumers, it is one of the most important water quality parameters. For example, for effective disinfection with chlorine, the pH should preferably be less than 8. The optimum range for chlorine disinfection is between pH 5.5 and 7.5. High pH causes a bitter taste, water pipes and water-using appliances become coated with deposits and it depresses the effectiveness of the disinfection of chlorine, thereby causing the need for additional chlorine when pH is high. Low pH water will corrode or dissolve metals and other substances.

2.3.4 Turbidity

Turbidity is a measure of the cloudiness/clarity of water. Cloudiness is caused by suspended solids mainly soil particles (sand, silt, clay), microscopic plants and animals that are suspended in the water column. Moderately low levels of turbidity may indicate a healthy, well-functioning ecosystem, with moderate amounts of microscopic plants and animals present to fuel the food chain. However, higher levels of turbidity pose several problems for stream systems. Higher turbidity levels are often associated with higher levels of viruses, parasites and some bacteria because they can sometimes attach themselves to the dirt in the water. Therefore, we must be cautious of turbid water as it usually has more pathogens, so drinking it increases our chances of becoming sick. Turbidity blocks out the light needed by submerged aquatic vegetation. It also can raise surface water temperatures above normal because suspended particles near the surface facilitate the absorption of heat from sunlight.

Nephelometers measure the intensity of light scattered by the suspended particles. The result is a measurement of turbidity in Nephelometric turbidity units (NTU). The WHO Guideline for turbidity in drinking water is less than 5 NTU. The turbidity in excess of 5 NTU or 5JTU may be noticeable and consequently objectionable to the consumers. Highly turbid water reduces light penetration therefore affecting levels of photosynthesis, warming is increased due to absorption of sunlight, and it is generally aesthetically unpleasing. These particles decrease the passage of light through the water. Turbidity sensor measures the murkiness by measuring the quantity of light scattered at ninety degree.

Normally, turbidity sensor makes use of LDR and LED. Excessive turbidity or cloudiness, in drinking water is aesthetically unappealing and may also represent a health concern. Turbidity can provide food and shelter for pathogens. If not removed, turbidity can promote regrowth of pathogens in the distribution system, leading to waterborne diseases, which have caused significant cases of gastroenteritis. Although turbidity is not a direct indicator of health risk, numerous studies show a strong relationship between removal of turbidity and removal of protozoa. The particles of turbidity provide shelter for microbes by reducing their exposure to attack by disinfectants. Fortunately, traditional water treatment processes have the ability to effectively remove turbidity when operated properly.

2.3.5 BOD

Biochemical oxygen demand or known as BOD is a chemical procedure for determining the amount of dissolved oxygen needed by aerobic biological organisms in the water to break down organic material present in a given water sample at certain temperature over a specific time period. It is widely used as an indication of the organic quality of the water. It is most commonly expressed in milligrams of oxygen consumed per litter of sample during 5 days (BOD) of incubation at 20°C. The conventional standard method for the determination of BOD measures the microorganisms' oxygen consumption or respiration over a period of 5 days and it is reported as BOD (Liu *et al*., 2014). The BOD values obtained is [BOD5] = [DO] Final – [DO] Initial.

BOD directly affects the amount of dissolved oxygen in rivers or streams. The rate of oxygen consumption can be affected by these variables which temperature, pH, the presence of certain kinds of microorganisms, and the type of organic and inorganic material in the water. The greater the BOD, the more rapidly oxygen is depleted in the stream. This means less oxygen is available to higher forms of aquatic life. The consequences of high BOD are the same as those for low dissolved oxygen which are aquatic organisms become stressed, suffocate, and will die. BOD is affected by the same factors that affect dissolved oxygen. BOD measurement requires taking two measurements. One is measured immediately for dissolved oxygen (initial), and the second is incubated in the lab for 5 days and then tested for the amount of dissolved oxygen remaining (final).

This represents the amount of oxygen consumed by microorganisms to break down the organic matter present in the sample during the incubation period. Moreover, the sources of BOD is topsoil, leaves and woody debris, animal manure, effluents from pulp and paper mills, wastewater treatment plants, feedlots, and food-processing plants, failing septic systems, and urban storm water runoff.

2.3.6 COD

Chemical Oxygen Demand (COD) is a measurement of the oxygen depletion capacity of a water sample contaminated with organic waste matter. It is similar in function to Biochemical Oxygen Demand (BOD) because they both measure the amount of organic compounds in water and they are the most commonly used parameters for the characterization of wastewaters (Abdalla and Hamman, 2014).

Chemical oxygen demand (COD) does not differentiate between biologically available and inert organic matter, and it is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. COD values are always greater than BOD values, but COD measurements can be made in a few hours while BOD measurements take five days.

2.3.7 TSS

Total suspended solids (TSS) can be defined as all particles in water that will not pass through a glass fibber filter without an organic binder (USEPA 1971). This includes all organic and inorganic matter such as sediments, algae, and nutrients or metals that have attached to the particles. Total solids concentration is the total suspended solids in a water sample plus the total dissolved solids (TDS) in that sample. TDS particles are less than 2 µm, while all particles greater than 2 µm are considered TSS. The standard pore size of the glass fibber filter to be used for TSS experiments cannot be absolutely defined because of the physical nature of glass fibber filters. However, pore sizes of 2 µm or smaller should be used for TSS testing so that TDS does not highly skew test results. For the laboratory tests conducted during this research, a glass fibber filter with a nominal 1.5 µm pore size was utilized.

Sources of suspended solids are a natural part of the environment. Natural processes such as erosion, flooding, forest fires, wind, wave action, storms, and ice break-up can cause an increase in TSS concentrations in nearby water bodies (Waters

1995). The geology of each watershed affects the amount of runoff and the amount of suspended solids entering the respective water body. Particles that already exist in the water body such as algae, zooplankton, bacteria, detritus, and phytoplankton can be suspended solids, and bottom feeders can stir up sediments while removing vegetation from the stream or lake bed (Waters 1995).

Human activities such as construction and agriculture can increase the amount of erosion, leading to increased TSS concentrations (USEPA 1990). Dams and reservoirs can decrease TSS concentrations immediately downstream of the dam since more settling occurs in the created 6 reservoir. The sediment-hungry waters that flow downstream of the dam can increase stream bank sloughing and erosion (Kerr 1995). Dredging of rivers and ponds for navigation or recreation can suspend previously settled solids. Logging activities, mining, road construction and runoff from roads, and recreational boating and navigation can increase TSS concentrations.

Urban development increases the amount of runoff, thus increasing the amount of suspended solids in receiving waters. Finally, treatment processes such as wastewater treatment often increases suspended solids in receiving water bodies (Waters 1995). Not all water discharges are monitored for TSS, but state permits involving TSS regulations can be issued for activities such as dewatering processes from construction sites.

2.3.8 Ammoniacal Nitrogen (NH_3-N)

Ammonium Nitrate is in the first place a nitrogenous fertilizer representing more than 10% of the total nitrogen consumption worldwide. It is more readily available to crops than urea. In the second place, due to its powerful oxidizing properties is used with proper additives as commercial explosive.

It is applied as a straight material or in combination with calcium carbonate, limestone, or dolomite. The combination is called calcium ammonium nitrate (CAN) or ammonium nitrate-limestone (ANL) or various trade names and in compound fertilizers including nitro phosphates. It is also a principal ingredient of most liquid nitrogen fertilizers. The nitrogen in ammonium nitrate is more rapidly available to some crops than urea or ammonium sulphate; most crops take up nitrogen mainly in nitrate form; thus, ammonia Cal nitrogen must be converted to nitrate in the soil before it becomes effective. Many crops respond well to a mixture of ammonium and nitrate nitrogen. Even though the nitrification process is rapid in warm soil, it is slower in cool soil (10°C and below). Urea may cause seedling damage due to volatilization of ammonia, and ammonium sulphate is strongly acid forming. For these and reasons ammonium nitrate and CAN are effective fertilizers in zones with medium and low temperatures during the cropping period, especially in those with a short vegetation period.

2.3.9 Heavy metal

Heavy metals that was selected is Plumbum, Cadmium and Zinc,

2.3.9.1 Lead (Pb)

Lead (Pb) occurs naturally in the Earth's crust and is a heavy with high density, low melting, bluish to grey or bluish-grey metal. Yet, it is hardly discovered naturally as a metal. It is usually found mutual with two or more other elements to produce and form lead compounds. Lead today is mostly “secondary” and obtained from lead-acid batteries. It is reported that 97% of these batteries are recycled.

2.3.9.2 Cadmium (Cd)

Cadmium (cd) is associated with zinc, lead, and copper ores. It is a metal, which is found in the earth’s crust. The pure one is soft, silver-white metal. The soluble form of Cadmium in water is Cadmium chloride and cadmium sulphate. Cadmium is used for the following: batteries (83%), pigments (8%), coatings and plating (7%), stabilizers for plastics (1.2%), nonferrous alloys, photovoltaic devices, and other uses (0.8%). It is released to soil, water, and air by non-ferrous metal mining and refining, manufacture and application of phosphate enrichers, fossil fuel burning, and waste incineration and disposal. Cadmium can assemble in aquatic organisms and farming harvests. Its compounds may go through soil, yet its versatility relies upon various factors, for example, measure of organic matter and pH, which will shift relying upon the local environment. Ordinarily, it ties strongly to organic matter where it will be relentless in soil and be taken up by vegetation, in the end, entering the nourishment supply.

2.3.9.3 Zinc (Zn)

One of the most common elements in the Earth's crust is Zinc. It can be found in different places such as air, water, and soil in addition to food. Zinc characteristics is elemental (or metallic) form, its colour is a bluish-white, glittery metal. Zinc may burst into flame and it is powder is if stored in damp places. Metallic zinc has many uses in industry.

Most well-known uses of it is to coat steel and iron as well as other metals to avoid rust and corrosion and that named as galvanization process. To form alloys, metallic zinc is also mixed with other metals such as brass and bronze. It is also used to produce dry cell batteries. Chlorine, oxygen, and sulfur, can be merged with Zinc and other elements, to create zinc compounds. It might found at dangerous waste spots. Zinc compounds are zinc chloride, zinc oxide, zinc sulfate, and zinc sulfide. They are considered to be metal placed naturally in the environment as zinc sulfide. It is usually utilized in manufacturing. White paints, ceramics, and other products are made from Zinc sulfide and zinc oxide.

2.4 Phytoremediation

Phytoremediation is vast, emerging term which has been used in recent decades for group of green eco-friendly technologies that fundamentally based on plants which are aquatic, semiaquatic and terrestrial and related associated enzymes, microorganism and water consumption, uptake, remove, retain, transform, degrade or immobilize contamination, organic and/or inorganic with different origin, from soil, sediment and aquatic media or atmosphere (Mulbry et al., 2008; Ridzuan et al. 2010, Dhir 2013)

Phytoremediation can be applied in terrestrial and aquatic environments. It can be used as a preparative or finishing step for other clean-up technologies. Plants are aesthetically pleasing and these systems are relatively self-sustaining and cost-effective. Plants have involved a great diversity of genetic adaptations to handle the accumulated pollutants that occur in the environment. Growing, and in some cases harvesting the plants on a contaminated site as a remediation method is a passive technique that can be used to clean up sites with shallow, low to moderate levels of contamination.

Phytoremediation can be used to clean up metals, pesticides, solvents, explosives, crude oil, polyaromatic hydrocarbons and landfill leachates. It can also be used in river basin management through the hydraulic control of contaminants.However, if a quotation is short, in text quotation should be used.

2.5 Water Hyacinth

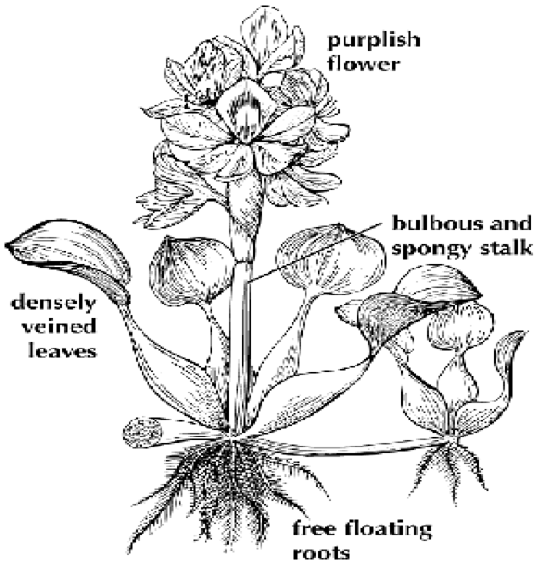

Figure 2.2   Water Hyacinth Plant

Eichhornia crassipes, commonly known as water hyacinth, is a type of floating aquatic macrophyte. Figure 2.2 above shows water hyacinth plant. Due to its characteristics of rapid proliferation, adaptation to a wide range of environmental condition and large nutrient uptake capacity, water hyacinth is considered as the suitable candidate for phytoremediation process. Water hyacinth is proven effective in removing various contaminants present in wastewater such as biochemical oxygen demand, chemical oxygen demand, total suspended solids, total dissolved solids, total solids, turbidity, heavy metals and nutrients (P.Moyo et al., 2013)

Water hyacinth is suitable for phytoremediation process is because of its characteristics and composition. Water hyacinth consists of 95% water and 5% of dry matter with high hemicellulose and cellulose content (R. Sindhu et al., 2017). Water hyacinth is type of aquatic plant that highly temperature-dependent species and it can be found in subtropical and tropical regions. However, water hyacinth cannot be found at the coastal area since the high salinity is the limiting factor towards the growth of water hyacinth. The seeds of water hyacinth remain viable below the water under unfavourable conditions which is in low temperature and light intensity for up to 20 years, making weed intervention methods complicated. Growth rate of water hyacinth is extremely fast, even though at beginning only a small number of water hyacinth, but in a short period of time, it can grow and proliferate to become a large number until covering the whole water. Figure 2.3 shows the water hyacinth plant lives in pond which in its habitat.

Figure 2.3 Water Hyacinth Plant in Pond

Instead of finding ways to eradicate the water hyacinth, making water hyacinth beneficial to social and environment is a better option. For instance, water hyacinth is widely used in phytoremediation process to clean up the varying pollutants in domestic and industrial wastewater. During early 1970s, as application of phytoremediation in wastewater treatment was in its early stage, water hyacinth had been reported to be used to treat various types of wastewater such as digested sugar factory wastes, dairies, palm oil production, distillery, natural rubber production, tannery, textile, electroplating, pulp and paper production, pesticide production and heavy metals (J. Vymazal et al., 2008).

After 1980s, the information regarding this topic was limited probably due to the uneconomical system issue. However, researches on water hyacinth as a phytoremediation plant was later revitalized at 2000s to explore the efficiency on treating various types of wastewater to remove both organic and inorganic contaminants. The examples of studies which made use of water hyacinth for water remediation included domestic wastewater, industrial wastewater, mixed domestic and industrial wastewater (Y.-C. Liang,. 2016), eutrophic lake, river water, heavy metals contaminated wastewater and radioactive wastewater.

In previous studied, numerous types of industrial wastewater have been studied for water hyacinth based phytoremediation process, which included agriculture eutrophic wastewater, pre-treated swine effluent, paper industry effluent, petrochemical wastewater, metallurgic wastewater, fertilizer manufacturing wastewater, mines wastewater and different wastewater sources which is from dairy farm, dairy processing plant, banana paper plant and landfill. Besides, several studies have employed water hyacinth to remove radionuclides (H.M. Saleh, 2012), ethions, herbicides, pharmaceuticals and personal care products (PPCPs) as well as to degrade polycyclic aromatic hydrocarbons (PAHs).

Besides, water hyacinth is considered as a promising aquatic plant for aquaponics, attributed to its good ability for absorbing pollutants, superior tolerance to contaminated environment, rapid growth (Zhang et al., 2014) and high economic value with diverse potential applications. Moreover, this plant superior heavy metal sorption and accumulation abilities compared to most other aquatic macrophytes. It has been well-established that water hyacinth, especially its roots, possesses a strong ability to remove heavy metals from aqueous solution, with the sorption performances vary depending on the metal species, concentration and solution chemistry (Gupta and Balomajumder, 2015). A high sorption of heavy metals, such as cadmium (Cd), zinc (Zn), chromium (Cr), lead (Pb), and copper (Cu), by water hyacinth or its routs have been demonstrated in previous studies.

Importantly, the sorption of different metals could be affected by each other, which is considered an important reason accounting for the usually large discrepancies in various sorption studies in complex natural water systems. Due to the very strong metal sorption and accumulation ability of the root relative to other parts of water hyacinth (Mishra et al., 2008), the competitive sorption of multiple metals by dried water hyacinth have been specifically investigated in several previous studies. For instance, Hasan et al. (2007) investigated the sorption of metal mixture by water hyacinth root and found a higher accumulation of Zn(II) over Cd(II). While, studies by Mahamadi and Nharingo (2010) showed that the sorption of Cd(II) and Zn(II) were suppressed by of Pb(II). Cu(II) was recently shown to also suppress the sorption of Cd(II) and Zn(II) by dehydrated root powder of a long-root water hyacinth (Li et al., 2016), indicating that competitive sorption of metals by water hyacinth is a universal phenomenon in natural aquatic system.

2.6 Treatment of Mechanism

Generally, there are five types of phytoremediation mechanisms to remove the pollutants. The types are phytovolatilization, phytodegradation, phytoextraction, rhizofiltration and phytostabilization (Paz-AlBerto et al., 2013). Phytovolatilization is the extraction and subsequent compounds release in gaseous form from the foliage into atmosphere. While, phytodegradation is the conversion of organic pollutants into non-toxic forms by plants and associated microorganisms which occurs at rhizosphere or plant internal. Meanwhile, phytoextraction is the natural ability of plant to take up substances like organic compounds from the environment and followed by sequestration of those substances inside plant cells. Rhizofiltration is the sorption of contaminants onto root surface or other plants parts, or the precipitation in the root zone. Lastly, phytostabilization is the immobilization of compounds in surrounding environment through the binding of the contaminants and chemicals released by plant. The type of phytoremediation mechanisms involved is depends on the type contaminants. Figure 2.4 shows types of pollutant that can be treated. While, table 2.2 shows different phytoremediation mechanism used to remediate varying pollutants.

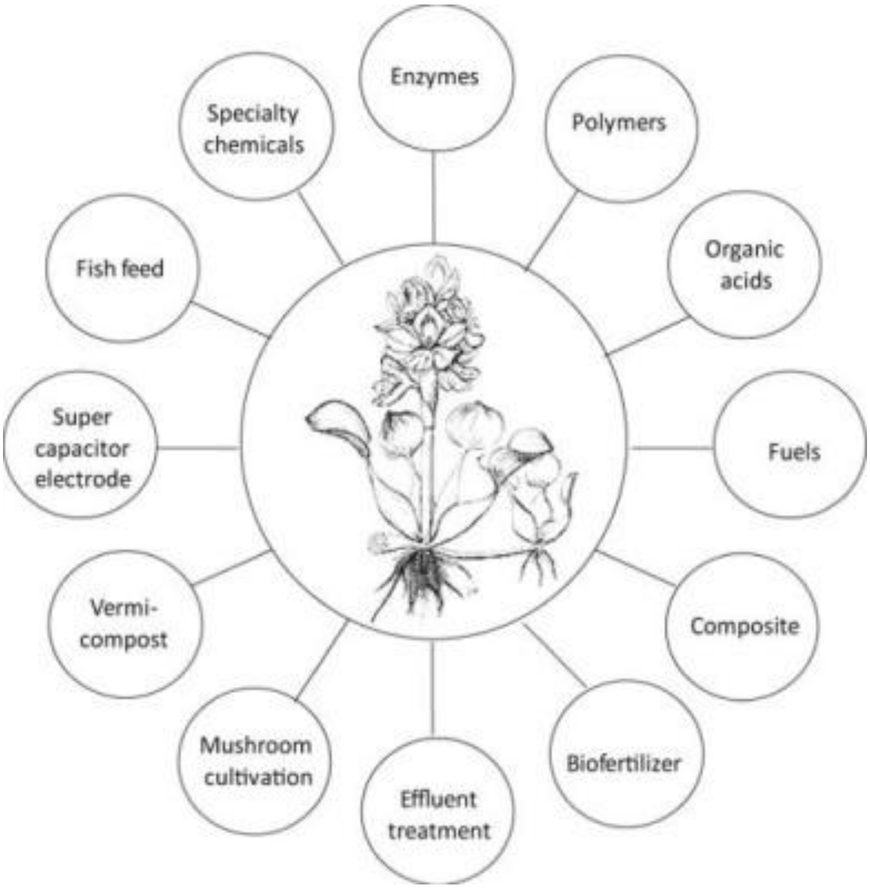

Figure 2.4 Types of pollutants that can be treated

Table 2.1 Different phytoremediation mechanisms used to remediate varying pollutants.

Type of contaminants	Mechanisms
Organic compounds	• Phytoextraction: Direct uptake and accumulation of contaminants and metabolism in plant tissues • Phytovolatilization: transpiration of volatile organic compounds (VOC) through the leaves • Rhizosphere bioremediation: release of exudates that stimulate microbial activity and biochemical transformations in the soil • Phytotransformation: Enhancement of mineralization into relatively nontoxic constituents such as carbon dioxide, nitrate, chlorine and ammonia at the root-soil interface
Nitrogen	• Biological: ammonification, nitrification, denitrification, plant uptake, biomass assimilation, dissimilatory nitrate reduction • Physico-chemical: ammonia volatilization, adsorption
Metals	• Phytoextraction: uptake and recovery of contaminants into above-ground biomass • Rhizofiltration: Filtering metals from water onto root • Phytovolatilization: metal ions are converted into volatile state
Radionuclide	• Sedimentation of radionuclides-containing suspended materials on the plant’s roots. • Plant assimilation

2.7 Results from Previous Researchers

Previously, a study was conducted by S. Fazal et al. in Biological Treatment of Combined Industrial Wastewater (2015) revealed that water hyacinth was efficient in reducing turbidity (92.5%), COD (83.7%), TSS (91.8%), TDS (62.3%), TS (80%), nitrates (67.5%), AN (71.6%), phosphates (90.2%), Cd (97.5%), Ni (95.1%), Hg (99.9%) and Pb (83.4%) present in industrial wastewater.

Another study by A. Valipour et al. in 2017 which is, Effectiveness of Domestic Wastewater Treatment using a Bio-hedge Water Hyacinth Wetland System also studied on domestic wastewater treatment using water hyacinth and obtained significant contaminants reduction of COD (79%), BOD (86%), TSS (73%), TN (77%), AN (72%), total phosphate (45%), PO4 3 (39%), total coliforms (94%), and total viable counts (96%).

CHAPTER 3

METHODOLOGY

3.1 Introduction

Research methodology is generally a flow of the research and detail about the research from the beginning until end of the project implementation. Methodology should be in wise and smooth planning in order to avoid any inconvenience circumstances while doing the task. There are some preparation needs to be carry out the planning work smoothly. All information that I get and gather are from journals, books and website. These resources are important in order to complete the project. Other than that, the visit to Gebeng Industrial area is very significant to our research. This is because, at there, the samples of wastewater are collected. Generally, research methodology explained the laboratory test method that used along this research.

3.2 Research location

The research location that has been identified in order to take the sample of the industrial wastewater is at the water river at industrial area, Gebeng. Meanwhile, the location to collect the plant sample, water hyacinth is at Sg Isap, Kuantan. Plants that needed to do for experiment is 30 which each sample, I used 10 plants only. To make sure all plant absorb the nutrient equally, the plant that are collected should be same size.

3.3 Methodology Flow chart

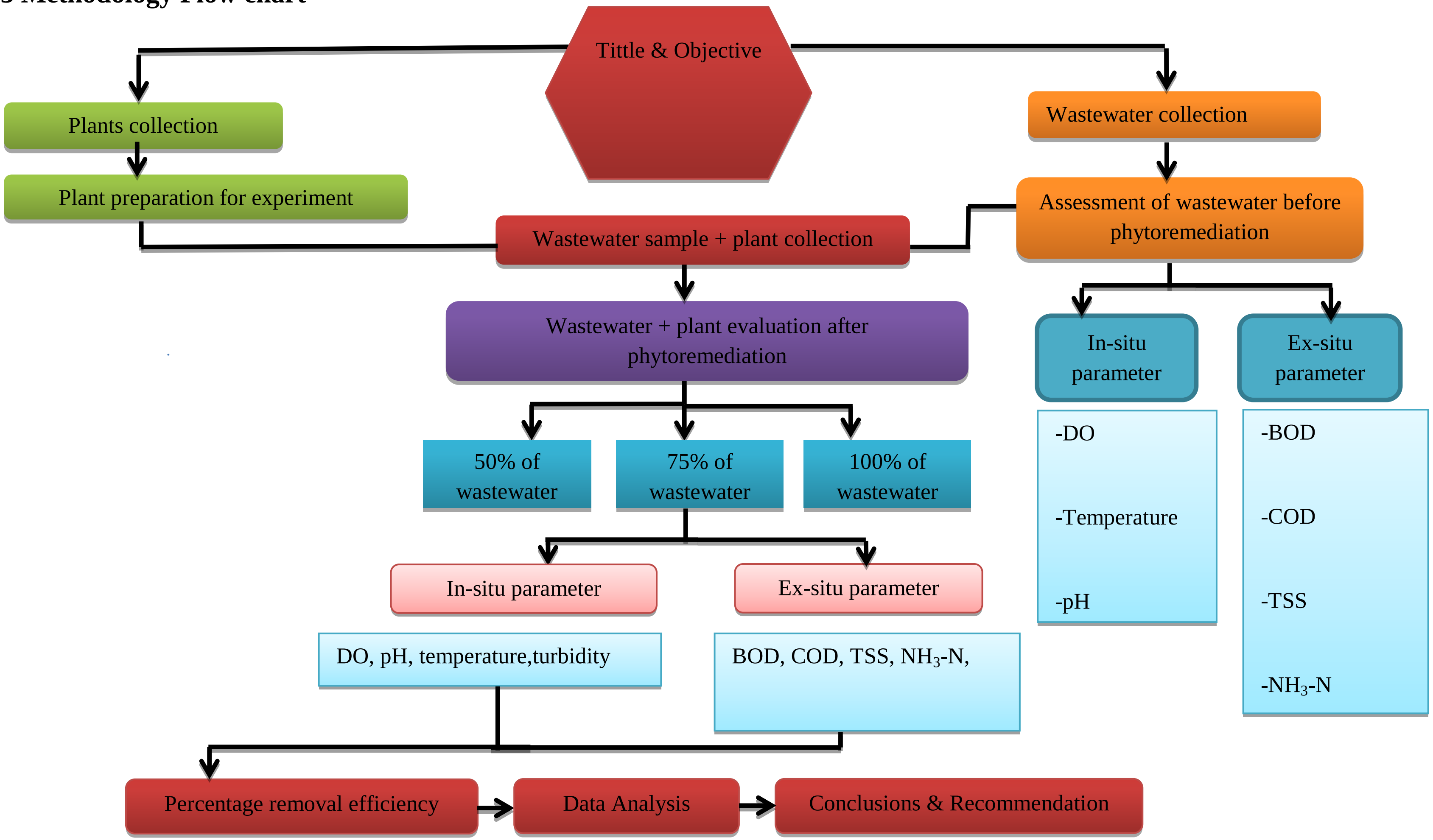

Figure 0.1 Methodology Flow Chart

3.4 Water hyacinth (*Eichhornia Crassipes)* collection + preparation

The collections of water hyacinths were taken at pond near Sg. Hisap. The water hyacinths were collected almost 40 sticks with same size. This is because to make sure all of the each water hyacinth absorbs same nutrients.

Before started doing this study, the water hyacinths were prepared after the collection. Firstly, water hyacinths were washed with tap water to remove any dirty that attached to the water hyacinth. Then, the water hyacinths were washed again with distilled water. This is because to remove any algae growth at the water hyacinth. So, water hyacinths become clean. Then, the water hyacinths were put into the three samples of distilled water for one week before started. This to make all of the water hyacinth did not get any nutrients yet until this study begin.

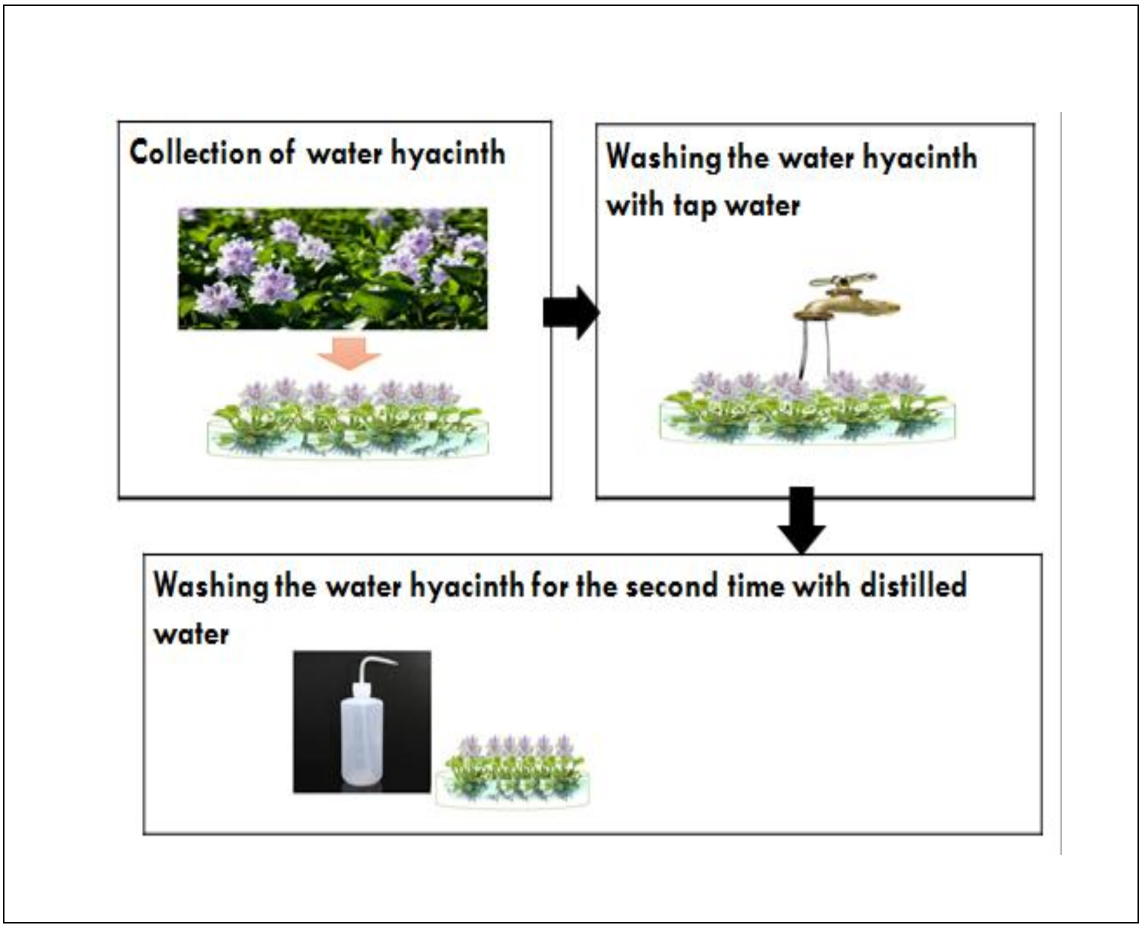

Figure 0.2 Process Preparation of Water Hyacinth

3.5 Sample collection + preparation

The samples of the industrial wastewater were collected at Gebeng Industrial Area. The samples were collect 30 L in total because each of the samples was used 10 L. When conducted this study, the concentration of sample was divided into 3 samples as figure 3.2 shows the concentration of samples. Sample A only used 50% of wastewater, sample B used 75% of wastewater and sample C is totally 100% of wastewater.

Concentration of sample

Sample A — 50% of wastewater

Sample B — 75% of wastewater

Sample C — 100% of wastewater

Figure 0.3 Concentration of Samples

3.6 Sample preparation for phytoremediation

For all the three samples, 10 sticks of water hyacinth plant were used for each sample. The sizes of water hyacinth for all samples are in same size. The figure 3.3 shows sample A of this study where 10 sticks of water hyacinth were put in a container with 50% of wastewater and 50% of distilled water. Figure 3.4 shows sample B with 10 sticks of water hyacinth were put in a container with 75% of wastewater and 25% of distilled water. Figure 3.5 shows sample C with 10 sticks of water hyacinth were put in a container with 100% of wastewater.

Sample A

- 50% of wastewater + 50% of distilled water
- The volume of wastewater is 5 L
- The volume of distilled water is 5L

Figure 0.4 Sample A

Sample B

- 75% of wastewater + 75% of distilled water
- The volume of wastewater is 7.5 L
- The volume of distilled water is 2.5 L

Figure 0.5 Sample B

Sample C

- 100% of wastewater
- The volume of wastewater is 10 L

Figure 0.6 Sample C

3.7 Parameter used in Experimental

There are 2 parameters used which are in-situ parameter and ex-situ parameter. In-situ parameter is the parameters that were conducted at site, while, for ex-situ parameter is the parameters that were done at laboratory. Table 3.1 shows in-situ parameter while table 3.2 shows ex-situ parameter.

3.7.1 In-situ parameter

At site, in-situ parameters that were done were DO, temperature, pH and turbidity.

Table 0.1 In-situ parameter

No	**Parameter**	**Unit**	**Equipment**
1	DO	mg/L	YSI 6600-V2 Multipaarmeter Sonde
2	Temperature	^{O}C	YSI 6600-V2 Multipaarmeter Sonde

3	pH	-	YSI 6600-V2 Multipaarmeter Sonde
4	Turbidity	NTU	-HACH Model 2100 Turbidimeter

3.7.2 Ex-situ parameter

At environmental laboratory UMP, ex-situ parameters that were done were BOD, COD, TSS, NH_3-N and heavy metals. Equation 3.1, 3.2, 3.3, 3.4 and 3.5 shows the formula to calculate BOD, COD, TSS, NH_3-N and heavy metals respectively.

Table 0.2 Ex-situ parameter

No	**Parameter**	**Unit**	**Method**	**Standard Code** **APHA/HACH**
1	BOD	mg/L	Azide Modofication Method	APHA 5210 B=
2	COD	mg/L	Open Reflux Method	APHA 5220 B=
3	TSS	mg/L	Salicilate Method	DR5000 Method 8155
4	NH_3-N	mg/L	Nessler Method	APHA 4500-NH_3 (B and C)
5	Lead (pb)	mg/L	Dithizone Method	APHA 3500 -Pb(B)=
6	Cadmium (cd)	mg/L	Dithizone Method	APHA 3500 -Cd(B)=

7	Zinc (zn)	mg/L	Dithizone Method	APHA 3500 -Cd(B)=

3.7.2.1 BOD

It is used as a measure of organic pollution as a basic for estimating the oxygen needed for biological process, and as an indicator of process performance.

$$\text{Organic matter} + O_2 \longrightarrow CO_2 + H_2O + \text{new cells}$$

Calculation of BODt

$$BODt = \frac{DOi - DOt}{P} \qquad 3.1$$

Where,

BODt = biochemical oxygen demand, mg/L

DOi = initial DO of the diluted wastewater sample about 15 min. after preparation, mg/L

DOt = final DO of the diluted wastewater sample after incubation for five days, mg/L

P = dilution factor

$$= \frac{Volume\ of\ sample}{Volume\ of\ sample + Volume\ of\ distilled\ water}$$

3.7.2.2 COD

COD is used to define the strength of industrial wastewaters. COD is calculated from the following equation:

$$COD = \frac{8000\ (a-b)}{V}\ x\ \ Normality\ of\ Fe\ (NH_4)_2(SO_4)_2 \qquad 3.2$$

Where:

a = amount of ferrous ammonium sulphate titrant added to blank, mL

b = amount of titrant added to sample, Ml

V = volume of sample, Ml

8000 = multiplier to express COD in mg/L of oxygen

COD/BOD = 2, only for biodegradable organics

COD >> BOD, non-biodegradable organics

3.7.2.3 TSS

$$\text{Total Suspended Solid} = \frac{(A-B)X\ 100}{C} \qquad 3.3$$

Where:

A = Weight of filter and disc + residue

B = Weight of filter and dish

C = Volume of sample filtered

3.7.2.4 NH_3-N

$$\mathbf{NH^3 - N = \frac{TAN\ X\ 10pH}{e}} \qquad 3.4$$

Where:

NH_3-N = Ammonia concentration as nitrogen, mg/L

TAN = Total ammonia nitrogen concentration, mg/L

pH = pH value

^{0}C = Temperature

3.7.2.5 Heavy metals

Heavy metals including lead (pb), cadmium (cd), zinc (zn). So, the formula removal efficiency is

$$\% \ R = \frac{C0-C}{C0} X\ 100 \qquad 3.5$$

Where:

C_0 = Initial parameter concentration of test solution, mg/L

C = Final parameter concentration of test solution, mg/L

3.8 Data recorded

Week	Initial		
	50% + 50%	75% + 75%	100%
0			
1			
2			
3			

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter discussed the results of study that have been carried out experimentally by using three samples, which classified according its concentration. The first sample (A) is 50% of wastewater and 50% of distilled water. The second sample (B) is 75% of wastewater and 25% of distilled water. The third sample (C) is 100% of wastewater. The sample is taken at river located at Gebeng industrial. This experiment is significant in order to determine the effectiveness of the water hyacinth in treating wastewater and also how efficiency its can remove excessive pollutant in wastewater. Phytoremediation is the elimination of the pollutants by the use of plants offers a promising technology for heavy metal removal from wastewater (Miretzky et al., 2004)

This test that have been done in research are DO, temperature, pH value, turbidity, BOD, COD, TSS, NH_3-N, and heavy metal which are Plumbum (pb), Cadmium (cd), Zinc (zn). These entire tests are related to each other in order to know its effectiveness towards the wastewater.

Table 0.1 For sample A which 50% of wastewater with 50% of distilled water.

Parameters	0^{th} week	1^{st} week	2^{nd} week	3^{rd} week
Dissolved oxygen (DO), mg/l	5.01	5.45	6.14	7.09
Temperature, ˚c	26.0	27.1	28.4	28.5
pH	11.90	9.60	8.20	7.31
Turbidity, NTU	12.14	9.32	8.07	7.00
Biochemical Oxygen Dissolved(BOD),mg/l	9.51	8.32	7.24	6.11
Chemical Oxygen Demand(COD), mg/l	40	31	28	15
Total suspended solids(TSS), mg/l	54	38	32	27
Ammoniacal Nitrogen(NH_3-N), mg/l	0.53	0.32	0.17	0.08
Plumbum (pb)	0.055	0.036	0.017	0.009
Cadmium (cd)	0.022	0.014	0.009	0.005
Zinc (zn)	0.037	0.026	0.018	0.011

Table 0.2 For sample B which 75% of wastewater with 25% of distilled water.

Parameters	**0^{th} week**	**1^{st} week**	**2^{nd} week**	**3^{rd} week**
Dissolved oxygen (DO), mg/l	5.12	5.68	6.50	7.19
Temperature, ˚c	26.50	27.2	28.7	28.4
pH	11.94	9.63	8.30	7.43
Turbidity, NTU	12.34	9.56	8.40	7.19
Biochemical Oxygen Dissolved(BOD),mg/l	9.69	8.67	7.50	6.29
Chemical Oxygen Demand(COD), mg/l	43	39	32	24
Total suspended solids(TSS), mg/l	53	41	37	35
Ammoniacal Nitrogen(NH_3-N), mg/l	0.59	0.44	0.26	0.09
Plumbum (pb)	0.054	0.047	0.031	0.012
Cadmium (cd)	0.023	0.019	0.015	0.008
Zinc (zn)	0.038	0.029	0.020	0.019

Table 0.3 For sample C which 100% of wastewater

Parameters	**0^{th} week**	**1^{st} week**	**2^{nd} week**	**3^{rd} week**
Dissolved oxygen (DO), mg/l	5.32	6.01	6.69	7.34
Temperature, ˚c	26.50	27.1	28.6	28.7
pH	11.95	9.67	8.34	7.56
Turbidity, NTU	12.42	9.81	8.62	7.44
Biochemical Oxygen Dissolved(BOD),mg/l	9.78	8.90	7.72	6.53
Chemical Oxygen Demand(COD), mg/l	41	40	37	29
Total suspended solids(TSS), mg/l	59	45	41	34
Ammoniacal Nitrogen(NH_3-N), mg/l	0.60	0.47	0.31	0.11
Plumbum (pb)	0.560	0.051	0.039	0.023
Cadmium (cd)	0.030	0.026	0.021	0.017
Zinc (zn)	0.039	0.032	0.027	0.022

4.2 Analysis of Results

4.2.1 Dissolved Oxygen (DO), mg/l

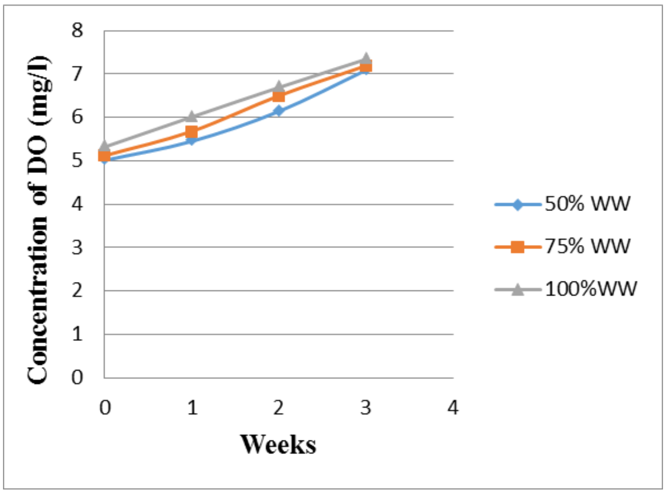

Figure 0.1 DO graph

From figure 4.1 above shows the value of DO for each week for 3 weeks according its concentration of wastewater. For initial week, the value of sample A which 50% of wastewater is 5.01 mg/l, while for sample B with 75% of wastewater is 5.12 mg/l and for sample C with 100% of wastewater is 5.32 mg/l. From the 1st week to 3rd week, we can see the value of DO is increasing for all concentration of wastewater. For 50% of wastewater, from week 1 to week 3, the value of DO is 5.45, 6.14, and 7.09 mg/l. For 75% of wastewater, from week 1 to week 3, the value of DO is 5.68, 6.50, and 7.19 mg/l. For 100% of wastewater, from week 1 to week 3, the value of DO is 6.01, 6.69, and 7.34 mg/l.

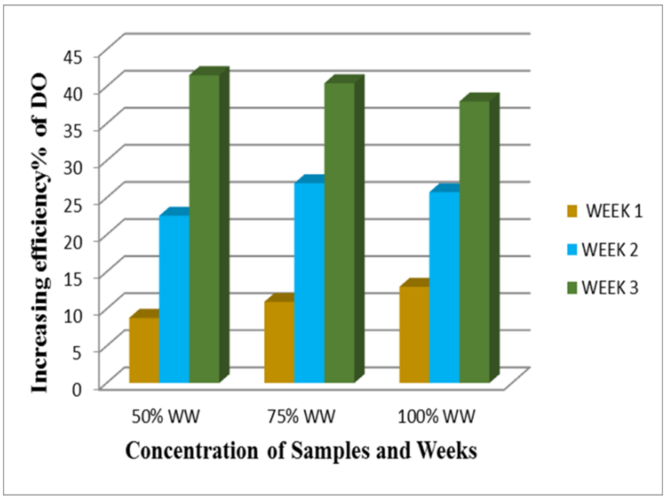

Figure 0.2 Increasing efficiency% of DO at different concentration and weeks

From figure 4.2 above shows increasing efficiency% of DO. At the end of week 3, the concentration of 50% of wastewater, the increasing efficiency% of DO is 41.52%. While, for the concentration of 75% of wastewater, the increasing efficiency% of DO is 40.43%. For the concentration of 100% of wastewater, the increasing efficiency% of DO is 37.97%. So, this shown, phytoremediation process is suitable in taking place in the sample of 50% of wastewater, since the DO value is the highest in this sample compared with the two others.

4.2.2 Temperature, ˚c

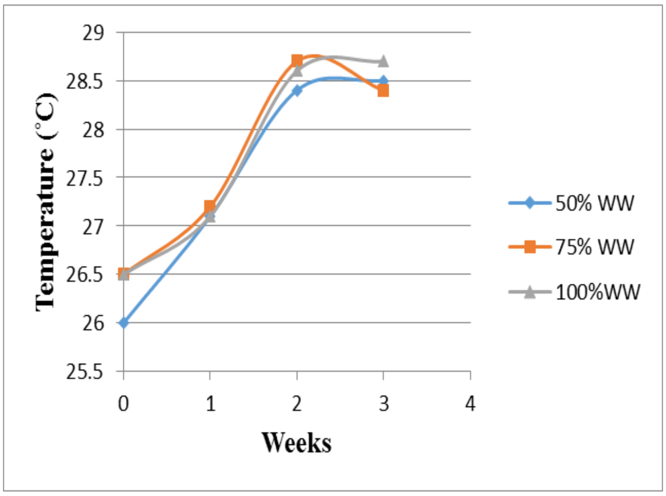

Figure 0.3 Temperature, ˚c graph

Figure 4.3 above shows the temperature in each week for 3 weeks. For initial value of temperature at initial week, the values are around 26 to 26.50 ˚c for all concentrations of sample. For week 1, the temperature is around 27.1 ˚c to 27.2 ˚c for 50%, 75% and 100%. While, for week 2 and week 3, the temperature is around 28.4 ˚c to 28.7 ˚c for the three samples. This temperature is suitable for experiment to be conducted.

4.2.3 pH value

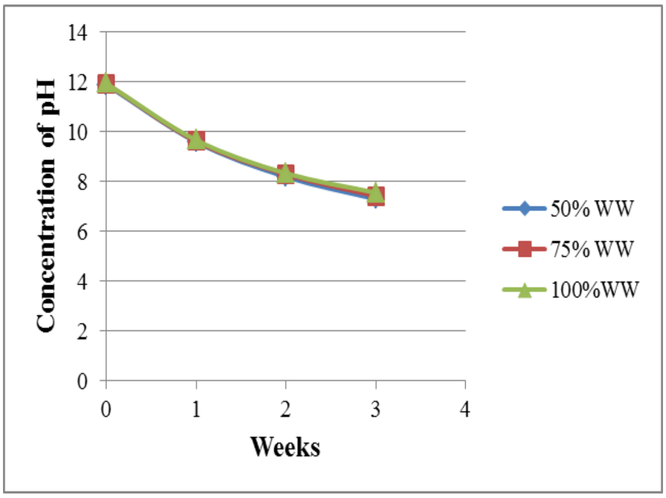

Figure 0.4 pH graph

Figure 4.4 above shows the pH value of each week for 3 weeks according its concentration of wastewater. As overall value, I can conclude that the water hyacinth is good in treating this wastewater, from alkali to neutral. As we can see, from initial week to third week, all the concentrations of samples, the value of pH is shows decreasing. For sample A which is 50% of wastewater, the value of pH is 11.9 mg/l decreasing to 7.31 mg/l at the third week. While, for sample B which is 75% of wastewater, the value of pH is 11.94 mg/l decreasing to 7.43 mg/l at the end. Same goes for sample C which 100% of wastewater, the pH value is decreasing from 11.95 mg/l to 7.56 mg/l at the third week.

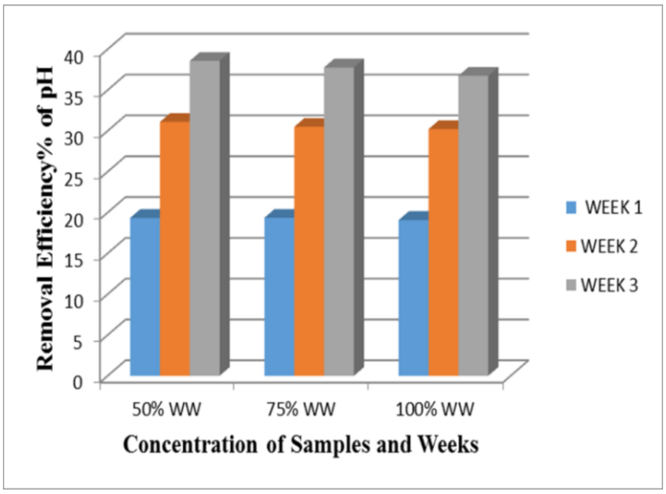

Figure 0.5 Increasing efficiency% of pH at different concentration and weeks

Figure 4.5 above shows removal efficiency% of pH, from the graph, the value removal efficiency% of pH for all the concentration of sample which 50%, 75% and 100% of wastewater is decreasing from initial to third week. This result is good because its show the water hyacinth is good in treating wastewater which turns the wastewater from alkali to neutral.

4.2.4 Turbidity, NTU

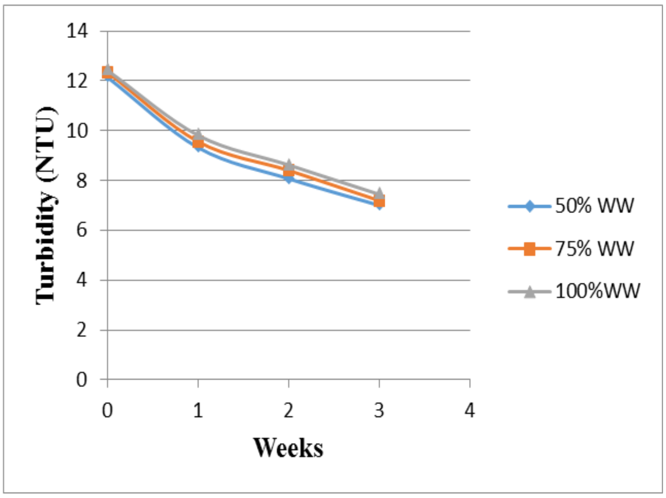

Figure 0.6 Turbidity, NTU graph

From figure 4.6 above shows the turbidity graph. From this graph, the value of turbidity for all concentration of wastewaters is decreasing from the initial week to third week. From this we can said that by weeks the wastewater become clean. At initial week, all the turbidity value for the three concentrations of samples is around 12.14 to 12.42 mg/l, while at the third week, all the value decrease to below and 7.44 mg/l.

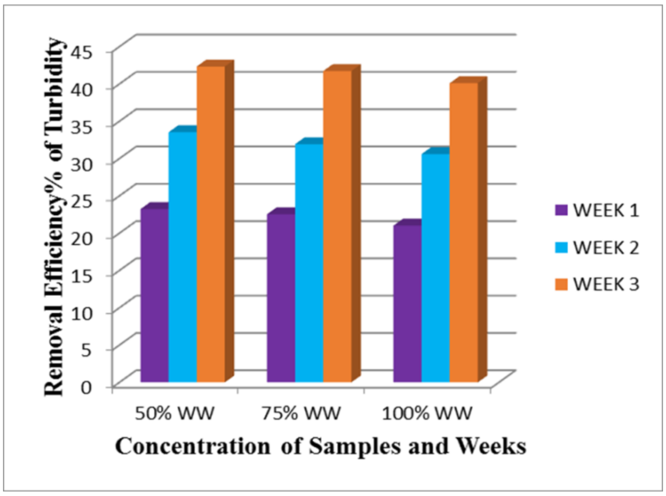

Figure 0.7 Removal efficiency% of turbidity at different concentration and weeks

Figure 4.7 above shows the removal efficiency% of turbidity graph. At the end of week 3, the concentration of 50% of wastewater, the removal efficiency% of turbidity is 42.34%. While, for the concentration of 75% of wastewater, the removal efficiency% of turbidity is 41.73%. For the concentration 100% of wastewater, the removal efficiency% of turbidity is 40.10%.

4.2.5 Biochemical Oxygen Demand (BOD), mg/l

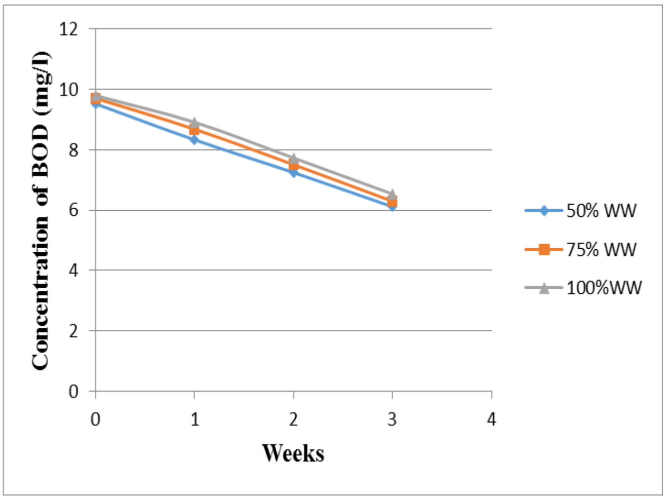

Figure 0.8 Biochemical Oxygen Demand (BOD), mg/l graph

From figure 4.8 above shows the value of BOD each week for 3 weeks according its concentration of wastewater. For initial week, the value of sample A which 50% of wastewater is 9.51 mg/l, while for sample B with 75% of wastewater is 9.69 mg/l and for sample C with 100% of wastewater is 9.78 mg/l. From the 1st week to 3rd week, we can see the value of BOD is decreasing for all concentration of wastewater as the graph shown decreasing. For 50% of wastewater, from week 1 to week 3, the value of BOD is 8.32, 7.24, and 6.11 mg/l. For 75% of wastewater, from week 1 to week 3, the value of BOD is 8.67, 7.50, and 6.29 mg/l. For 100% of wastewater, from week 1 to week 3, the value of BOD is 8.90, 7.72, and 6.53 mg/l.

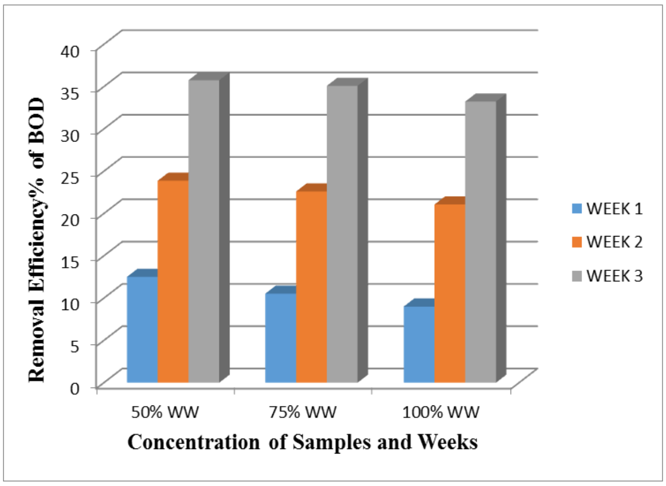

Figure 0.9 Removal efficiency% of BOD at different concentration and weeks

Figure 4.9 above shows the removal efficiency% of BOD graph. At the end of week 3, the concentration of 50% of wastewater, the removal efficiency% of BOD is 35.75%. While, for the concentration of 75% of wastewater, the removal efficiency% of BOD is 35.09%. For the concentration of 100% of wastewater, the removal efficiency% of BOD is 33.23%. So, this shown, phytoremediation process is suitable in taking place in sample of 50% of wastewater, since the BOD value is the highest in this sample compared with the two others.

4.2.6 Chemical Oxygen Demand (COD), mg/l

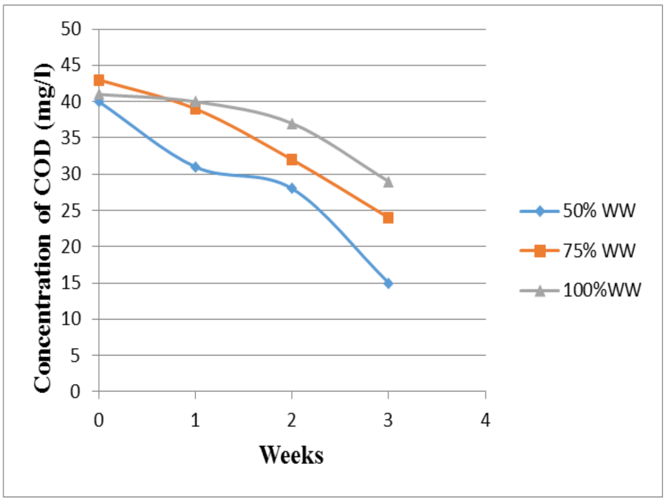

Figure 0.10 Chemical Oxygen Demand (COD), mg/l graph

From figure 4.10 above shows the value of COD each week for 3 weeks according its concentration of wastewater. For initial week, the value of sample A which 50% of wastewater is 40 mg/l, while for sample B with 75% of wastewater is 43 mg/l and for sample C with 100% of wastewater is 41 mg/l. From the 1st week to 3rd week, we can see the value of COD is decreasing for all concentration of wastewater as the graph shown decreasing. For 50% of wastewater, from week 1 to week 3, the value of COD is 31, 28 and 15 mg/l. For 75% of wastewater, from week 1 to week 3, the value of COD is 39, 32 and 24 mg/l. For 100% of wastewater, from week 1 to week 3, the value of COD is 40, 37, and 29 mg/l.

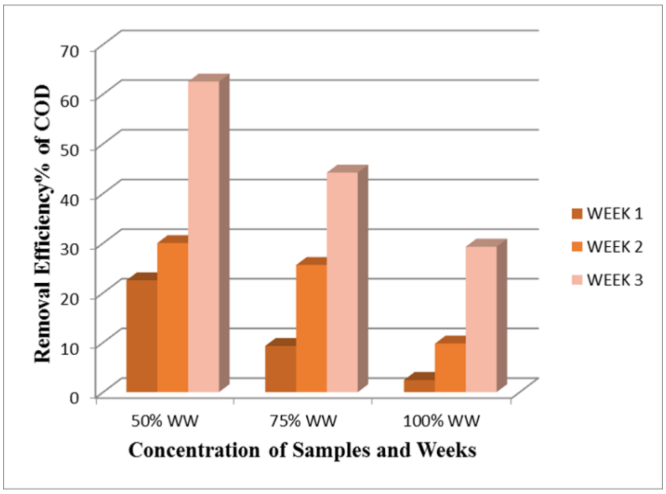

Figure 0.11 Removal efficiency% of COD at different concentration and weeks

Figure 4.11 above shows the removal efficiency% of COD graph. At the end of week 3, the concentration of 50% of wastewater, the removal efficiency% of COD is 62.50%. While, for the concentration of 75% of wastewater, the removal efficiency% of COD is 44.19%. For the concentration of 100% of wastewater, the removal efficiency% of COD is 29.27%. So, this shown, phytoremediation process suitable in taking place in sample of 50% of wastewater, since the COD value is the highest in this sample compared with the two others.

4.2.7 Total Suspended Solid (TSS), mg/l

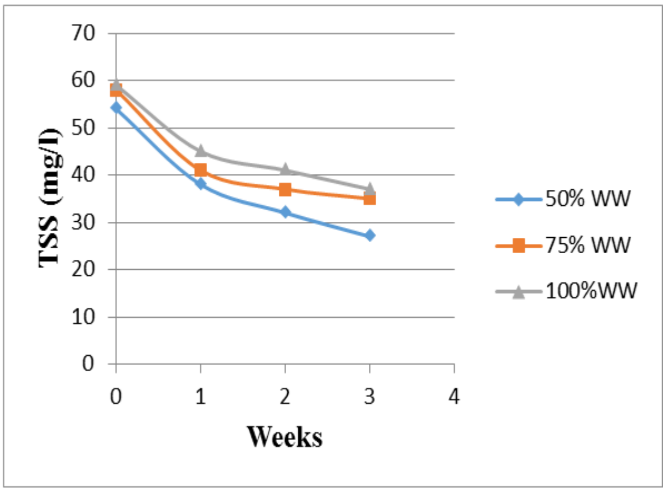

Figure 0.12 Total Suspended Solid (TSS), mg/l graph

Figure 4.12 above shows TSS graph. This graph shows the value of TSS each week for 3 weeks according its concentration of wastewater. The graph is decreasing of the value of TSS. For all concentration of wastewaters, the initial value of TSS is around 54 mg/l to 59 mg/l. At the end of the week, all the values are decreased. Value decreased to 27 mg/l for 50% of wastewater. For 75% of wastewater, the value decreased to 35 mg/l. While, 100% of wastewater, it decreased to 37 mg/l.

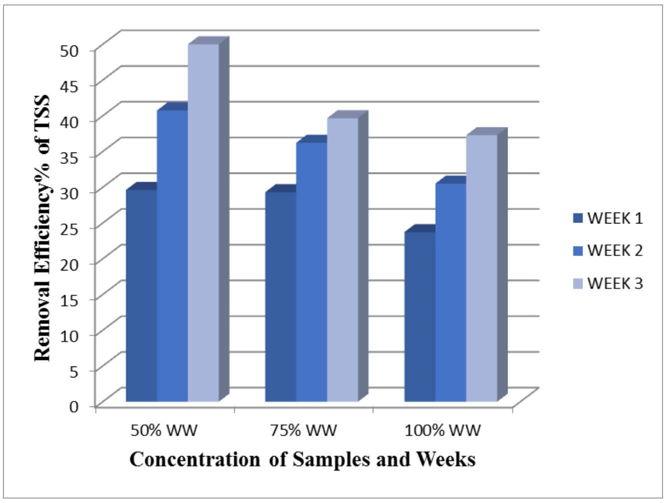

Figure 0.13 Removal efficiency% of TSS at different concentration and weeks

Figure 4.13 above shows removal efficiency% of TSS graph. At the end of week 3, the 50% of wastewater, the value of removal is 50%, while for 75% of wastewater, the value of removal is 39.66% and for 100% of wastewater, the value of removal is 37.29%. So, this shown, phytoremediation process is suitable in taking place in sample of 50% of wastewater, since the TSS value is the highest in this sample compared with the two others.

4.2.8 Ammoniacal Nitrogen (NH_3-N), mg/l

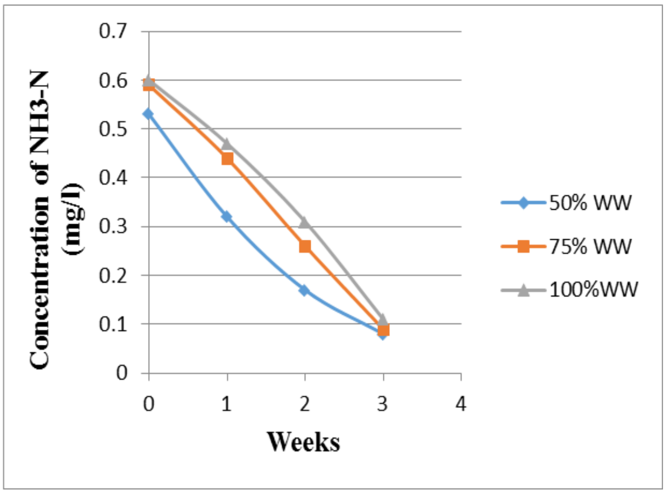

Figure 0.14 Ammoniacal Nitrogen (NH_3-N), mg/l

Figure 4.14 above shows NH_3-N graph. This graph shows the value of NH_3-N each week for 3 weeks according its concentration of wastewater. The graph is decreasing of the value of NH_3-N. For all concentration of wastewaters, the initial value of NH_3-N is around 0.50 mg/l to 0.60 mg/l. At the end of the week, all the values are decreased. Value decreased to 0.08 mg/l for 50% of wastewater. For 75% of wastewater, the value decreased to 0.09 mg/l. While, 100% of wastewater, it decreased to 0.11 mg/l.

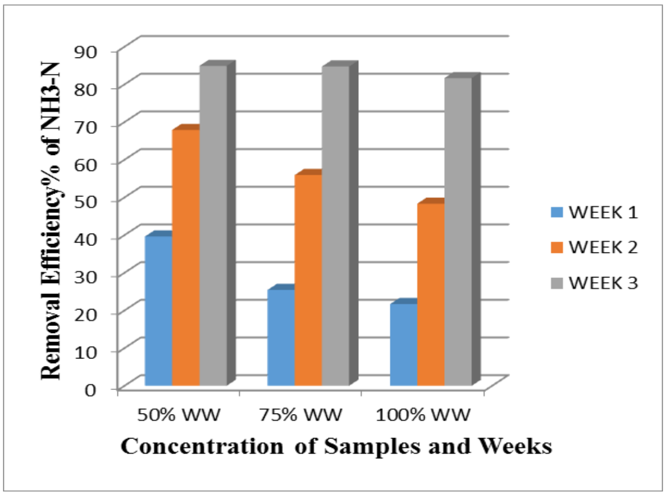

Figure 0.15 Removal efficiency% of NH_3-N at different concentration and weeks

Figure 4.15 above shows removal efficiency% of NH3-N graph. At the end of week 3, the 50% of wastewater, the value of removal is 84.91%, while for 75% of wastewater, the value of removal is 84.75% and for 100% of wastewater the value of removal is 81.67%. So, this shown, phytoremediation process suitable in taking place in sample of 50% of wastewater, since the value NH3-N is the highest in this sample compared with the two others.

4.2.9 Plumbum (pb), mg/l

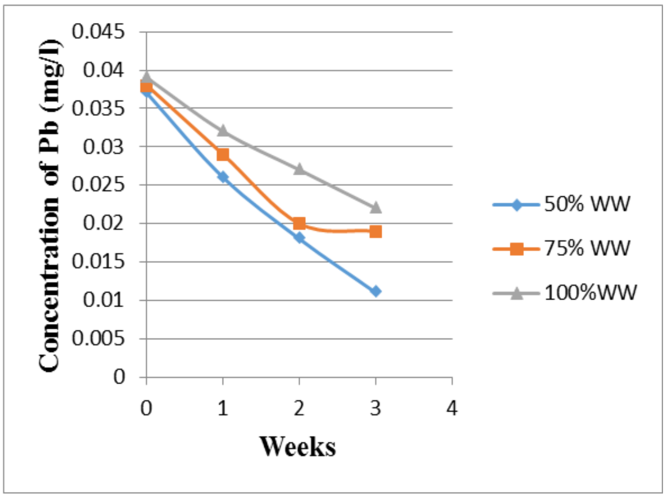

Figure 0.16 Plumbum (pb), mg/l, graph

Figure 4.16 above shows Plumbum graph for 3 weeks according its concentration of wastewater. Concentration of plumbum is decreasing within 3 weeks. As we can see, from initial week to third week, all the concentrations of samples, the value of plumbum is shows decreasing. For sample A which is 50% of wastewater, the value of plumbum is 0.037 mg/l decreasing to 0.011 mg/l at the third week. While, for sample B which is 75% of wastewater, the value of plumbum is 0.038 mg/l decreasing to 0.019 mg/l at the end. Same goes for sample C which 100% of wastewater, the plumbum value is decreasing from 0.039 mg/l to 0.022 mg/l at the third week.

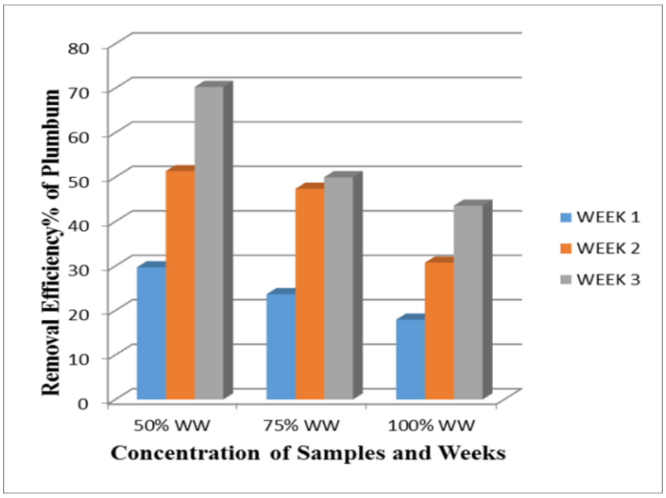

Figure 0.17 Removal efficiency% of pb at different concentration and weeks

Figure 4.17 above shows removal efficiency% for Plumbum graph. At the end of week 3, the 50% of wastewater, the value of removal is 70.27%, while for 75% of wastewater, the value of removal is 50% and for 100% of wastewater, the value of removal is 43.59%. So, this shown water hyacinth is effective in removing heavy metals such as plumbum.

4.2.10 Cadmium (cd), mg/l

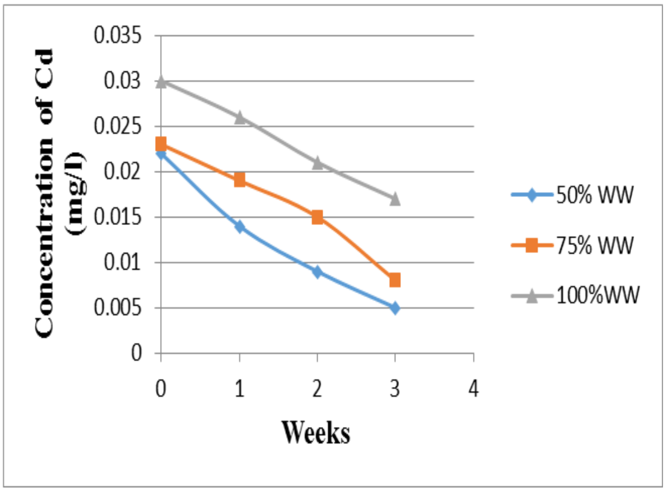

Figure 0.18 Cadmium (cd), mg/l graph

Figure 4.18 above shows Cadmium graph for 3 weeks according its concentration of wastewater. Concentration of cadmium is decreasing within 3 weeks. As we can see, from initial week to third week, all the concentrations of samples, the value of cadmium is shows decreasing. For sample A which is 50% of wastewater, the value of cadmium is 0.022 mg/l decreasing to 0.005 mg/l at the third week. While, for sample B which is 75% of wastewater, the value of cadmium is 0.023 mg/l decreasing to 0.008 mg/l at the end. Same goes for sample C which 100% of wastewater, the cadmium value is decreasing from 0.03 mg/l to 0.017 mg/l at the third week.

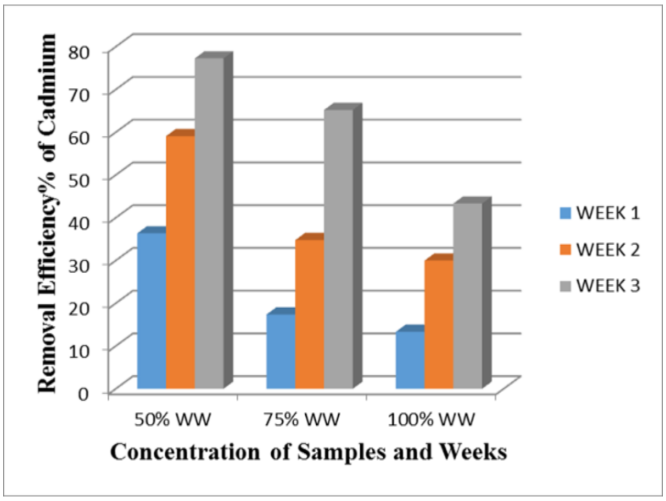

Figure 0.19 Removal efficiency% of cd at different concentration and weeks

Figure 4.19 above shows removal efficiency% for Cadmium graph. At the end of week 3, the 50% of wastewater, the value of removal is 77.27%, while for 75% of wastewater, the value of removal is 65.22% and for 100% of wastewater, the value of removal is 43.33%. So, this shown water hyacinth is effective in removing heavy metals such as cadmium.

4.2.11 Zinc (zn), mg/l

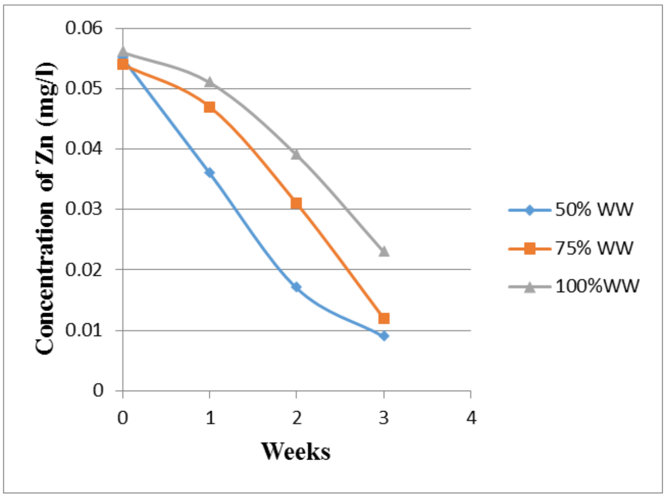

Figure 0.20 Zinc (zn), mg/l graph

Figure 4.20 above shows Zinc graph for 3 weeks according its concentration of wastewater. Concentration of zinc is decreasing within 3 weeks. As we can see, from initial week to third week, all the concentrations of samples, the value of cadmium is shows decreasing. For sample A which is 50% of wastewater, the value of zinc is 0.055 mg/l decreasing to 0.009 mg/l at the third week. While, for sample B which is 75% of wastewater, the value of zinc is 0.054 mg/l decreasing to 0.012 mg/l at the end. Same goes for sample C which 100% of wastewater, the zinc value is decreasing from 0.056 mg/l to 0.023 mg/l at the third week.

2.2.1

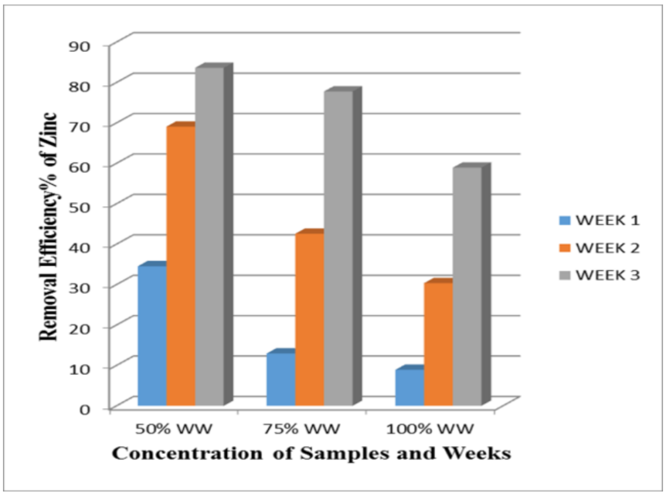

Figure 0.21 Removal efficiency% of zn at different concentration and weeks

Figure 4.21 above shows removal efficiency% for Zinc graph. At the end of week 3, the 50% of wastewater, the value of removal is 83.64%, while for 75% of wastewater, the value of removal is 77.78% and for 100% of wastewater, the value of removal is 58.93%. So, this shown water hyacinth is effective in removing heavy metals such as zinc.

CHAPTER 5

CONCLUSION

4.3 Introduction

This study that is on tittle “The effectiveness of water hyacinth (*Eichhornia Crassipes*) in treatment of Water River at industrial area, Gebeng has been successfully done. From the result obtained and analysis that have been done, it can be conclude that the purpose of this study has been achieved. This study is to determine the potential of water hyacinth (*Eichhornia Crassipes*) in industry wastewater treatment and to investigate the pollution reduction efficiency of water hyacinth (*Eichhornia Crassipes*) for removal of excessive pollutant from wastewater. This chapter comprise of two parts which is conclusion and recommendation. The conclusion and recommendation are subjected to the objective and study scope from chapter 1.

4.4 Conclusions

In this chapter, the findings of the effectiveness of water hyacinth in treatment of Water River at industrial area, Gebeng, where the phytoremediation process is used will be discussed and evaluated. Phytoremediation is a process where water hyacinth (*Eichhornia Crassipes*) absorbs the contaminated in the water river. This study is done by classified into three samples which are different in concentration of the water river and will test for some parameters including for removal of heavy metals. The heavy metals that have been determined in this study are Plumbum, Cadmium and Zinc. As a result, sample A with 50% of wastewater is the good concentration for the water hyacinth (*Eichhornia Crassipes*) in treating water river at industrial area, Gebeng.

The findings that obtained from the result are the value of DO has been decreased. This is because of the water hyacinth absorbing the oxygen for their growth. The value of DO decreased from 5.01 mg/l to 7.09 mg/l at the end of week 3. The decrement values for removal efficiency% obtained are firstly, pH value is 38.57%, BOD 35.75%, COD 62.5%, DO 41.52%, turbidity 42.32%,TSS 50%, and NH_3-N 90%. All the results from the analysis of parameters indicate that it has a massive potential for removal of the wide range of pollutants from wastewater (Chua, 1998, Maine et al., 2001, Sim, 2003, Mangabeira et al., 2004) and has the ability to grow in highly contaminated waters (So et al., 2003).

For heavy metals which are Plumbum, Cadmium and Zinc has shown the decrement in its value. The value percentages of decrement are Pb 70.27%, Cd 77.27% and Zn 83.64%. It can be proven that water hyacinth (*Eichhornia Crassipes*) is effective in removing heavy metals of river water at industrial area, Gebeng. It also can conclude that the water hyacinth is an excellent aquatic plant, which all the value of the removal efficiency% for all parameters is successfully removed. Floating plants have the ability to pile up the heavy metals from surrounding water and it mainly accumulates in the aerial parts (Valittuto et al., 2006).

At the end of this research, by using phytoremediation in water treatment it can reduce the contaminant in the water river. This process is environmental friendly and low cost since it is using plant, the natural resources. It may provide an affordable technology for small and medium scale industry. So, we can conclude water hyacinth (*Eichhornia Crassipes*) has the potential to be used as an eco-friendly and economic material for the removal of heavy metals.

After carry out this research as well, the plant species that has been used in phytoremediation method could be identified further, for example water hyacinth (*Eichhornia Crassipes*) is effective in removing toxic metal effluent.

4.5 Recommendations

As everyone knows, water is the most important resource on the planet. It is essence of all life on earth. But, nowadays, we can see polluted water on river or lake around us especially near to the industrial area. This condition is not good since the polluted water are dangerous to us and can give bad impacts on human health, aquatic lives and environmental. So, as prevention to prevent it becomes serious issues, phytoremediation can be performed in order to ensure protection of public health and environment.

Below are some recommendations for this research that need to be considered in order to reduce the contaminated water from industrial area:

1) The information and knowledge need to be expand abroad so the community will noticed about the phytoremediation advantages and also practical
2) The different type of aquatic plants and more parameters should be analysed to know the more efficiency of the phytoremediation process
3) Phytoremediation can be used in all industry since it wants to reduce the contaminant of polluted water.

In order to improve this research, there are several things should be stress out in the future. Another parameter of study should be increase so that the result can be clearly justified and proved.

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APPENDIX A
SAMPLE APPENDIX 1

Table 0.1 Increasing Efficiency of DO (mg/l)

Week	Increasing Efficiency of DO (mg/l)		
	Sample A: 50% Wastewater + 50% Distilled water	Sample B: 75% Wastewater + 15% Distilled water	Sample C: 100% Wastewater
0	8.78	10.94	12.97
1	22.56	26.95	25.75
2	41.52	40.43	37.97

Table 0.2 Removal Efficiency of pH value

Week	Removal Efficiency of pH value		
	Sample A: 50% Wastewater + 50% Distilled water	Sample B: 75% Wastewater + 15% Distilled water	Sample C: 100% Wastewater
0	19.33	19.35	19.08
1	31.09	30.49	30.21
2	38.57	37.77	36.74

Table 0.3 Removal Efficiency of Turbidity (NTU)

Week	Removal Efficiency of Turbidity (NTU)		
	Sample A: 50% Wastewater + 50% Distilled water	Sample B: 75% Wastewater + 15% Distilled water	Sample C: 100% Wastewater
0	23.23	22.53	21.01
1	33.53	31.93	30.60
2	42.34	41.73	40.10

Table 0.4 Removal Efficiency of BOD (mg/l)

Week	Removal Efficiency of BOD (mg/l)		
	Sample A: 50% Wastewater + 50% Distilled water	Sample B: 75% Wastewater + 15% Distilled water	Sample C: 100% Wastewater
0	12.51	10.53	9.00
1	23.87	22.6	21.06
2	35.75	35.09	33.23

Table 0.5 Removal Efficiency of COD (mg/l)

Week	Removal Efficiency of COD (mg/l)		
	Sample A: 50% Wastewater + 50% Distilled water	Sample B: 75% Wastewater + 15% Distilled water	Sample C: 100% Wastewater
0	22.50	9.30	2.44
1	30.00	25.58	9.76
2	62.50	44.19	29.27

Table 0.6 Removal Efficiency of TSS (mg/l)

Week	Removal Efficiency of TSS (mg/l)		
	Sample A: 50% Wastewater + 50% Distilled water	Sample B: 75% Wastewater + 15% Distilled water	Sample C: 100% Wastewater
0	29.63	29.31	23.73
1	40.74	36.21	30.51
2	50.00	39.66	37.29

Table 0.7 Removal Efficiency of NH_3-N (mg/l)

Week	Removal Efficiency of NH_3-N (mg/l)		
	Sample A: 50% Wastewater + 50% Distilled water	Sample B: 75% Wastewater + 15% Distilled water	Sample C: 100% Wastewater
0	39.62	25.42	21.67
1	67.92	55.93	48.33
2	84.91	84.75	81.67

Table 0.8 Removal Efficiency of pb (mg/l)

Week	Removal Efficiency of pb (mg/l)		
	Sample A: 50% Wastewater + 50% Distilled water	Sample B: 75% Wastewater + 15% Distilled water	Sample C: 100% Wastewater
0	29.73	23.68	17.95
1	51.35	47.37	30.77
2	70.27	50	43.59

Table 0.9 Removal Efficiency of cd (mg/l)

Week	Removal Efficiency of cd (mg/l)		
	Sample A: 50% Wastewater + 50% Distilled water	Sample B: 75% Wastewater + 15% Distilled water	Sample C: 100% Wastewater
0	36.36	17.39	13.33
1	59.09	34.78	30
2	77.27	65.22	43.33

Table 0.10 Removal Efficiency of zn (mg/l)

Week	Removal Efficiency of zn (mg/l)		
	Sample A: 50% Wastewater + 50% Distilled water	Sample B: 75% Wastewater + 15% Distilled water	Sample C: 100% Wastewater
0	34.55	12.96	8.93
1	69.09	42.59	30.36
2	83.64	77.78	58.93

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