**Nutrients Removal Of Universiti Teknologi PETRONAS Sewage Treatment Plant Effluent Using Landscape Plants**

by

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13549

Dissertation submitted in partial fulfillment of

the requirements for the

Degree of Study (Hons)

(Civil)

MAY 2014

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the

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(CIVIL)

Approved by,

______________________________

(Dr. Shamsul Rahman Bin M Kutty)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

May 2014

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(NOR NADIAH BINTI ABDLLAH)

## ACKNOWLEDGEMENT

First and foremost, I would like express my utmost gratitude to God for the accomplishment of this work. It cannot be done without the help from my project supervisor Dr Shamsul Rahman. It is an honour to work under his sincere guidance.

I wish to acknowledge the laboratory technologists of Environmental Laboratory for their kindness assistance and willingness to help me in gaining the information about my project and executing the laboratory experiments.

Special thanks goes to all lecturers of Civil Engineering Department that impart their wisdom and knowledge and the supporting staffs and all of my friends for their cooperation and assistance throughout my degree's study in UTP and accomplishment of this final year project. Last but not least, thanks to all individual that impair apart either directly or indirectly of which contributed in the completing of this project and finishing the task given to me.

# ABSTRACT

Universiti Teknologi PERTONAS (UTP) has a municipal sewage treatment plant that treat wastewater form the whole university according to Standard A of Environmental Quality Act 1974 limit. However, the effluent of this treatment plant contains inorganic fertilizer-related chemicals such as ammonia, nitrate and phosphorus that can lead to the contamination of our water course through run-off or of our air through volatilization if it is excessive. This study is assessed the  of landscape plants for purification of nutrient enriched wastewater effluent using phytoremediation method to achieve zero discharge. Each landscape plant will be placed in each compartment and the water sample will be collected after one day detention time. As for the plant growth, observation will be conducted by observation of new young shoot development.

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# CHAPTER 1

# INTRODUCTION

## 1.1 BACKGROUND OF STUDY

Universiti Teknologi PETRONAS has a municipal sewage treatment plant that treat wastewater form the whole university according to Standard 'A' of Malaysia's Environmental Quality Act 1974 limit. However, the effluent of this treatment plant contains inorganic fertilizer-related chemicals such as ammonia, nitrate and phosphorus. According to National Oceanic And Atmospheric Administration (NOAA), excessive amount of these chemicals can lead to a build up of nutrients and encourage the overgrowth of algae. Therefore, one of the methods to remove the nutrients is by using phytoremediation. Phytoremediation is a post-treatment of the effluent that usually being used to remove heavy metals, nutrients, oil and other contaminant by using plants to absorb the contaminants (United States Environmental Protection Agency (USEPA), 2012). Phytoremediation helps in order to achieve zero discharge of the municipal sewage treatment plant. Figure 1.1 below explains briefly on how phytoremediation works.

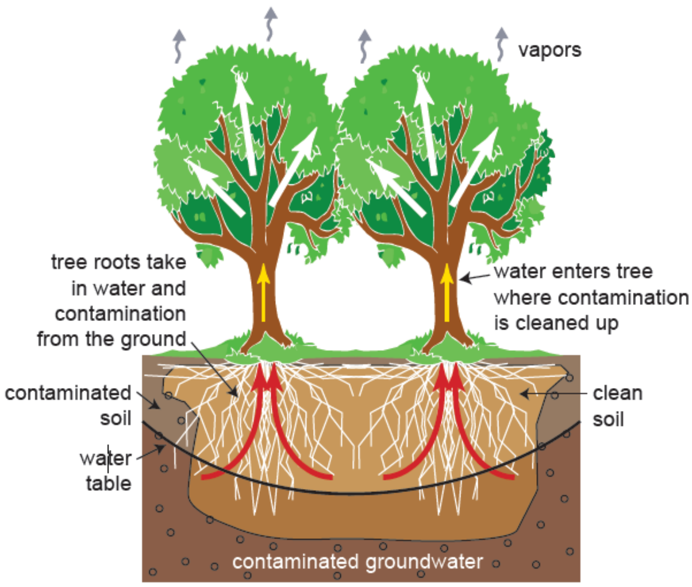


Figure 1: How Phytoremediation Works.

Source: USEPA (2012)

## 1.2 PROBLEM STATEMENT

Wastewater effluent with excessive amount of inorganic fertilizer-related chemicals can lead to a build up of nutrients and encourage the overgrowth of algae in the river. Phosphorus itself often regarded as the main element that caused eutrophication and blue baby syndrome. When the nutrients were discharged to the land, it will contaminate the soils and groundwater. Therefore, a study needs to be done to remove nutrients from the wastewater effluent to achieve zero discharge using landscape plants.

## 1.3 SCOPE OF STUDY

To scope of this study is to assess the suitability of landscape plants for purification of nutrient enriched wastewater effluent using phytoremediation method to achieve zero discharge from UTP sewage treatment plant.

## 1.4 OBJECTIVE OF THIS STUDY

1. To identify the removal efficiency of landscape plants in removal nutrients (nitrate, phosphorus and ammonia) from the effluent.
2. To recommend the implementation of phytoremediation to achieve zero discharge in UTP by using landscape plants.

## 1.5 RELEVANCY OF STUDY

The relevancy of this study is to recommend the implementation of phytoremediation in UTP to achieve zero discharge by using landscape plants. Phytoremediation is a method to remove contaminants in the water that is safe and cheap and easy. Landscape plants used is not only to absorb the contaminant, but also can be used for landscape in UTP.

## 1.6 FEASIBILITY OF STUDY

Based on the scope of work and time frame, this study is feasible. The landscape plants chosen are easy to grow as both of them are usually being planted around the house or city for landscape. It is also suitable with the site condition. Hence, before the end of this period, the research will be completed.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 NUTRIENTS AND WATER

According to Ward and Singh (2004), in the 45 year period of 1930-1975, the global human population has increased by approximately 2 billion, rising to 4 billion. A further population increase of 2 billion occurred in the 25-year interval 1975-2000 and population is expected to reach 8 billion by 2020. With the increasing of the population, human activities will be increased and it will directly cause uncontrolled contamination of soil, water and other media.

There are two major groups of environmental contaminants, namely chemical and biological wastes (Ward & Singh, 2004). Excessive level of inorganic fertilizer-related chemicals also known as nutrients, such as ammonia, nitrate and phosphorus can lead to the contamination. Nutrients can run off land in urban areas where lawn fertilizers are used. It will act like fertilizer and caused the excessive growth of algae and this process is called eutrophication (NOAA, n.d.).

When this process happened, phytoplankton will grow and reproduce rapidly, resulting in algal bloom. Next, it will disrupt the ecosystem as it may use up all oxygen in the water and leaving non for the other marine life and caused them died (Water Pollution Guide (WPG), n.d.). As for municipal sewage treatment plant, most activated sludge systems operated at low sludge age do not involve nitrification in the treatment. Therefore, treated effluent from this sewage treatment plant may contain undesirable concentrations of nutrients (Kutty, Ngatenah, Isa & Malakahmad, 2009).

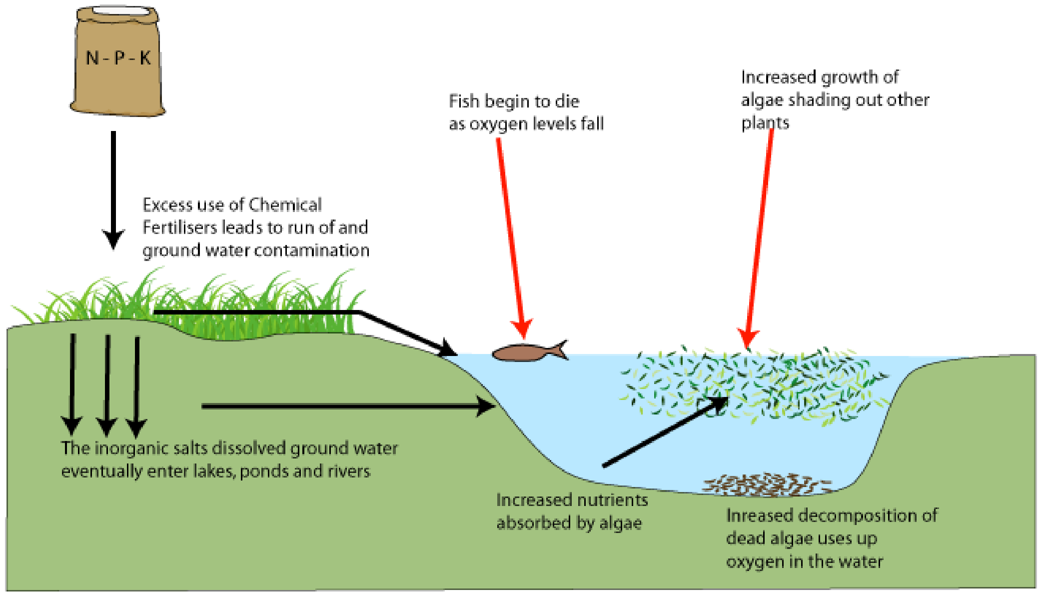


Figure 2: How Eutrophication Occurs.

Source: WPG, (n.d.)

## 2.2 PHYTOREMEDIATION

Phytoremediation is a post-treatment of the effluent that usually being used to remove heavy metals, nutrients, oil and other contaminant by using plants to absorb the contaminants. According to Raskin (1996), phytoremediation term was first used in 1991 proposal funded by USEPA. However, the use of plants in removing contaminants in the water has been occurring for at least 300 years ago (Cunningham & Berti, 1993).

Phytoremediation involves the use of plants, algae and fungi either to remove, control wastes or to spur waste breakdown by microorganisms in the rhizosphere (McCutcheon & Schnoor, 2003). The wastes that potentially can be managed by using phytoremediation are including heavy metals, radionuclides, nutrients, salts, sewage and etc.

There are six types of phytoremediation processes which are phytoextraction, phytosequestration, phytohydraulics, phytodegradation, rhizodegradation, phytostabilisation, phytotransformation, phytovolatilization and rhizofiltration (Hettiarachchi, Nelson, Agudelo-Arbelaez, Mulisa, & Lemunyon, 2012). According to McCutcheon and Schnoor (2003), rhizofiltration method is widely used in treating nitrate, ammonia and phosphate. Rhizofiltration involved a process where the compounds taken up, sorbed or prepicipated by roots.

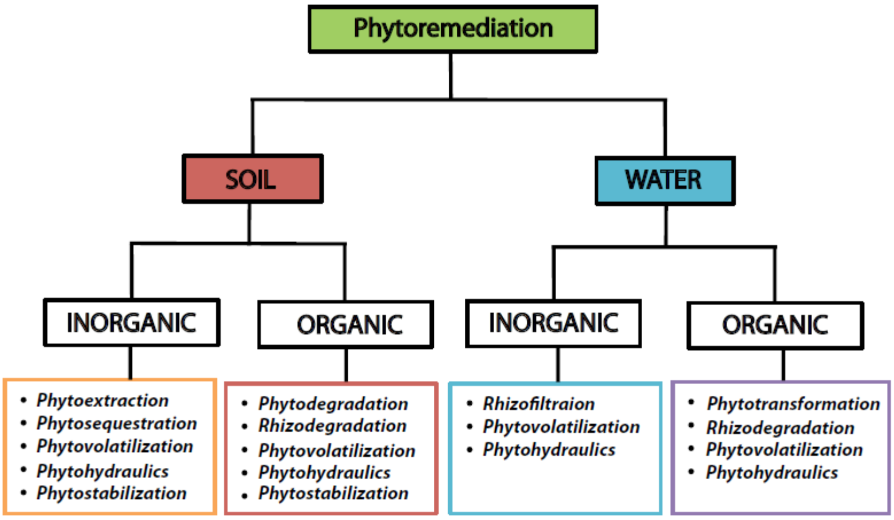


Figure 3: Application of Phytoremediation Mechanisms

Source: Hettiarachchi et al. (2012)

Rhizofiltration is applicable for the treatment of surface water and groundwater, industrial and residential effluents, downwashes from power lines, storm waters, acid mine drainage, agricultural runoffs, diluted sludges, and radionuclide-contaminated solutions (Rawat, Krishna, Fulekar & Phatak, 2012)

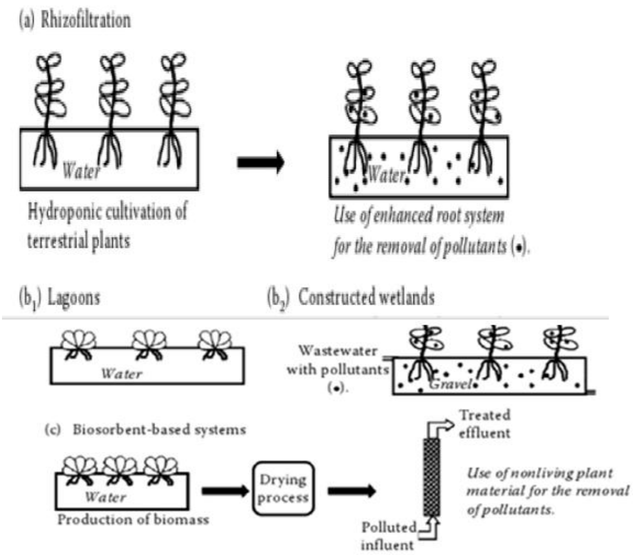


Figure 4: Preparation and operative stages of rhizofiltration lagoons, constructed wetlands, biosorbent- based systems.

Source: Rawat et al. (2012)

Phytoremediation have a lot of advantages. It can be used to clean up wide range of contaminants and can address multiple contaminants at one time. As an example, plant species may be able to remove an organic contaminant through phytovotalization and also remediate risk associate with inorganic contamination through phytostabilization. Hettiarachi et al. (2012) also mentioned that phytoremediation requires less maintenance and less external energy.

## 2.3 WETLANDS FOR WASTE TREATMENT

Wetlands for waste treatment are one existing practice that is increasingly a vital part of phytoremediation (Horne, 2000). In the past few decades, the interest in utilizing the abilities of constructed wetlands has been increased among governments and industries for processing and eliminating many of the harmful waste products of municipal, and even industrial, waste streams (Fields, 2004).

The construction of treatment wetlands in United States (U.S.) has been increased in the last two decades (Young, 1996). This due to the favourable aesthetics, capital costs, operation and maintenance const and the positive experience has gained. In US, current regulations favour using wetlands to treat sewage from towns of less than 5000 people (Horne, 2000)

Most of municipal wastewater is slightly tainted with soaps and detergents, though it is all treated the same by sewage system. Wastewater which goes down the drains of the shower, bathtubs, dishwasher, clothes washer and sinks is known as greywater contains fertilizer-related chemicals and it can be treated by using wetland treatment (Fields, 2004).

Created treatment wetlands are logical solution for waste streams containing excess organis carbon, nutrients, particulate matter and metals and in situations where the waste stream in under control and the land is available and cheap (McCutcheon & Schnoor, 2003). Performance data for wetland treatments have been summarized for the removal of biological oxygen demand, total suspended solids, pathogens, phosphorus, nitrogen, metals and trace organic compounds (Reed & Hines, 1993).

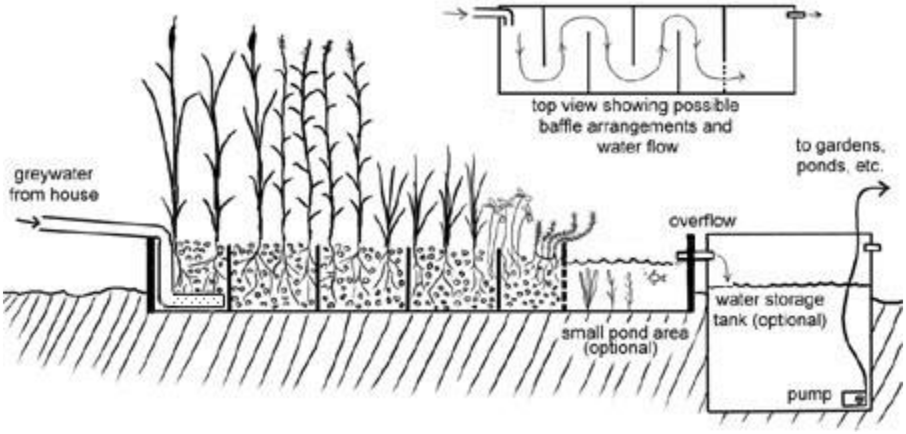


Figure 5: Schematic Diagram of a Phytoremediation Wetland.

Source: Fields (2004)

# CHAPTER 3

# METHODOLOGY

## 3.1 FABRICATION OF REACTORS

Four concrete reactors with baffled compartments and one overflow compartment will be used throughout the research. The dimensions of the reactors are as follows:

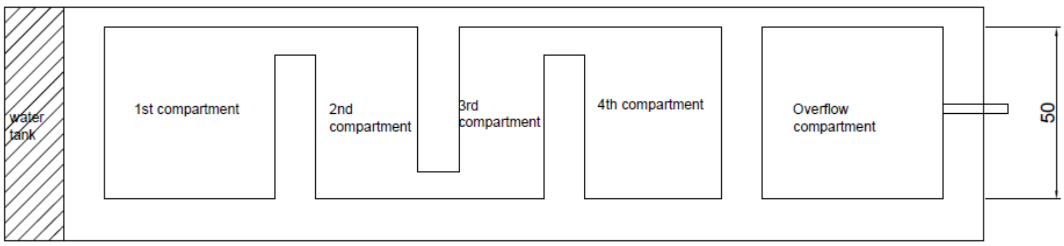


Figure 6: Reactor's Plan View

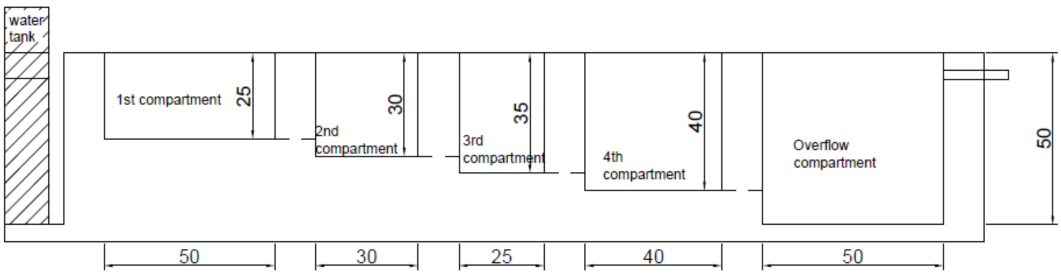


Figure 7: Reactor’s Cross Section

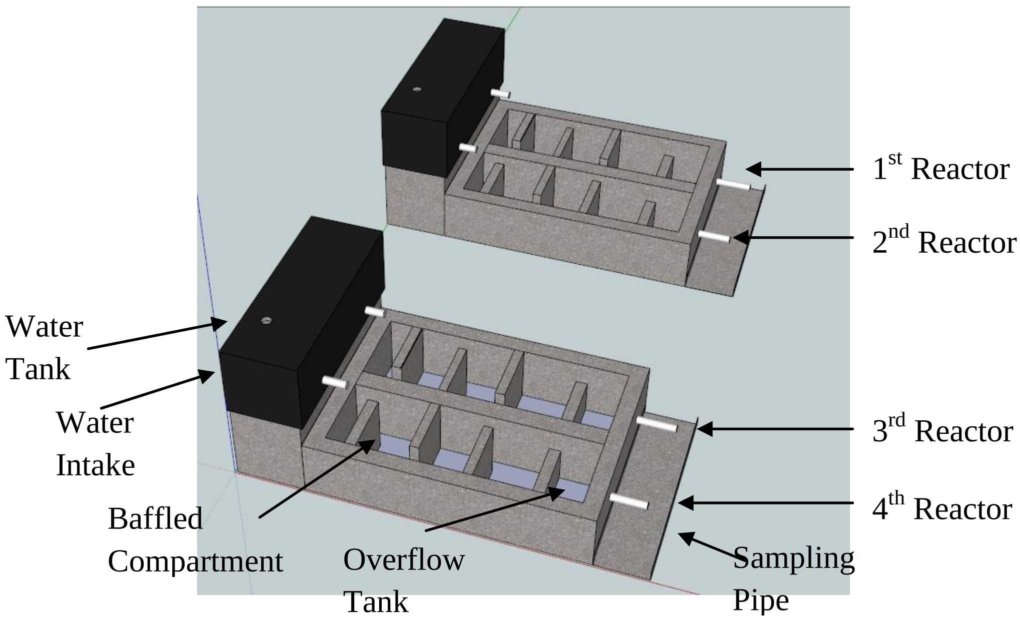


Figure 8: Reactor Design in 3D

### 3.2 EXPERIMENT METHODOLOGY

Several types of landscape plants e.g. Ixora, Bougainvillea and Codiaeum will be planted in each baffled compartment. 100% of red soil will be used for the first reactor while for the second reactor, sludge and red soil will be used with the ratio 1:1. The reason of choosing red soils instead of organic soil is because, it is low in nutrient and as the water intake already contains the nutrients, it is expected not to affect the results later. For the third and fourth reactors, will use water as base and aquatic plants will be planted in both reactors. The summaries of reactors unit are as follow:

| **Reactor** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|
| **Soil (%)** | 100 | 50 | - | - |
| **Sludge (%)** | - | 50 | - | - |
| **Water (%)** | - | - | 100 | 100 |
| **Plants** | Landscape | Landscape | Water Lily | Water Lettuce |

Table 1: Reactor's Unit during the Experiment

The water will be pumped from the STP effluent into the water tank and it will be tapped into the reactor with the flow rate approximately $3.33 \times 10^{-6}\ m^3/s$. After one day, sampling will be done at selected sampling points to measure the concentration of ammonia, phosphorus, nitrate and chemical oxygen demand (COD). Sampling will be done for 10 days. The plants will be observed for its growth throughout the research by observing new young shoot development. There are 4 sampling point for all reactors and the sampling point are as follow:

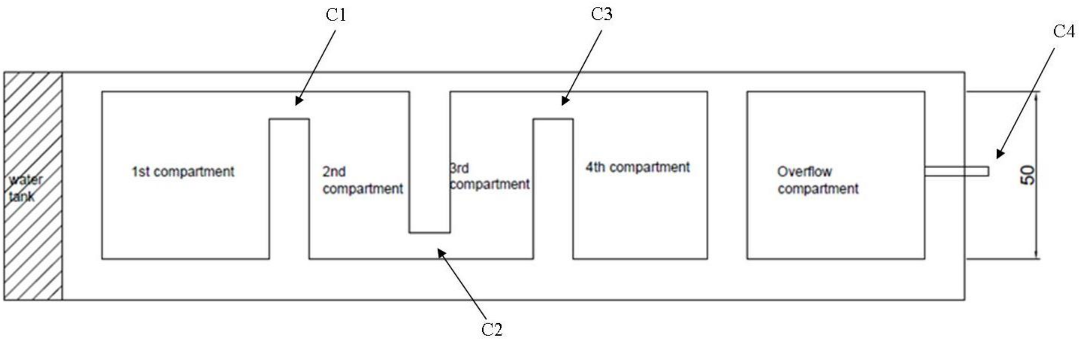


Figure 9: Sampling Points

## 3.3 MEASUREMENT OF PARAMETERS

### 3.3.1 Nitrate

10 mL of the sample is measured and poured into square sample cell. Then, a sachet of NitraVer 5 Nitrate Reagent Powder Pillow is added into the cell. The cell is shaken slowly to avoid bubbles for one minute. After that, the cell is left for 5 minutes to allow it to react. At the same time, 10 mL of the sample is measured and poured into another square sample cell for blank. Then, the blank cell is wiped and used to calibrate spectrophotometer to zero. As the time passes by, the sample cell is then wipe and 3 readings will be taken using spectrophotometer and the average of the reading will be calculated to get the accurate result.

### 3.3.2 Ammonia

The sample is diluted with ratio 1:5 to avoid over range reading. 25 mL of the dilution is measured using measuring cylinder. For blank, 25 mL of distilled water is measured using measuring cylinder. 3 drops of Mineral Stabilizer is added into both cylinders. The cylinders are then capped and shaken to mix it. Then, 3 drops of Polyvinyl Alcohol Dispersing Agent is added into the cylinders. The cylinders are then capped and shaken to mix it. Next, 1 mL of Nessler Reagent is added into the cylinders and then it will be capped and shaken. The solution is left for one minute to react. Then, 10 mL of the solution is poured into a square sample cell. Same procedure is done for blank. Blank square sample cell is wiped using damp cloth and spectrophotometer is zeroed. Then, the prepared sample is then wiped and 3 readings will be taken using spectrophotometer and the average of the reading will be calculated to get the accurate result.

### 3.3.3 Phosphorus

The experiment is started by pre-heat DRB200 reactor will to 150°C.. The sample is diluted with ratio 1:5 to avoid over range reading. Then, by using pipette, 5 mL of sample is measured and poured into a vial. Next, one sachet of Potassium Persulfate Powder Pillow is added into the vial. The vial is then capped tightly and shaken properly to dissolve the powder by using touch mixer. The vial is then put into the reactor for 30 minutes. After the time passes, the vials will be taken out and left cooled for about 20-30 minutes.

By using micropipette, 2 mL of Sodium Hydroxide Standard Solution is added into the vials. The vial is then capped tightly and shaken. Damp cloth is used to wipe outside the vial. Then, 3 readings will be taken using spectrophotometer and the average of the reading will be calculated to get the accurate result.

### 3.3.4 COD

The experiment is started by pre-heat DRB200 reactor will to 150°C. Then, 2 ml of the samples is measured and poured into a vial. For blank, 2 ml of distilled water is used. The vials are then capped tightly and shaken properly using touch mixer. Heat will be produced due to reaction in the vials indicating exothermic process. The vials will be put into the reactor for 2 hours. After the time passes, the vials will be taken out and left cooled for about 20-30 minutes. Damp cloth is used to wipe outside the vial. Then, 3 readings will be taken using spectrophotometer and the average of the reading will be calculated to get the accurate result.

### 3.4 GANTT CHART AND KEY MILESTONE

| No. | Details | Week | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1 | Project Work Continues | | | | | | | | | | | | | | | |
| 2 | Submission of Progress Report | | | | | | | | | | | | | | | |
| 3 | Project Work Continues | | | | | | | | | | | | | | | |
| 4 | Pre-SEDEX | | | | | | | | | | | | | | | |
| 5 | Submission of Dissertation (soft bound) | | | | | | | | | | | | | | | |
| 6 | Submission of Technical Paper | | | | | | | | | | | | | | | |
| 7 | Viva | | | | | | | | | | | | | | | |
| 8 | Submission of Project Dissertation (hard bound) | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | |

| | |
|---|---|
| | Process |

Table 2: Gantt chart FYP2

# CHAPTER 4

# RESULT AND DISCUSSION

## 1. Nitrate

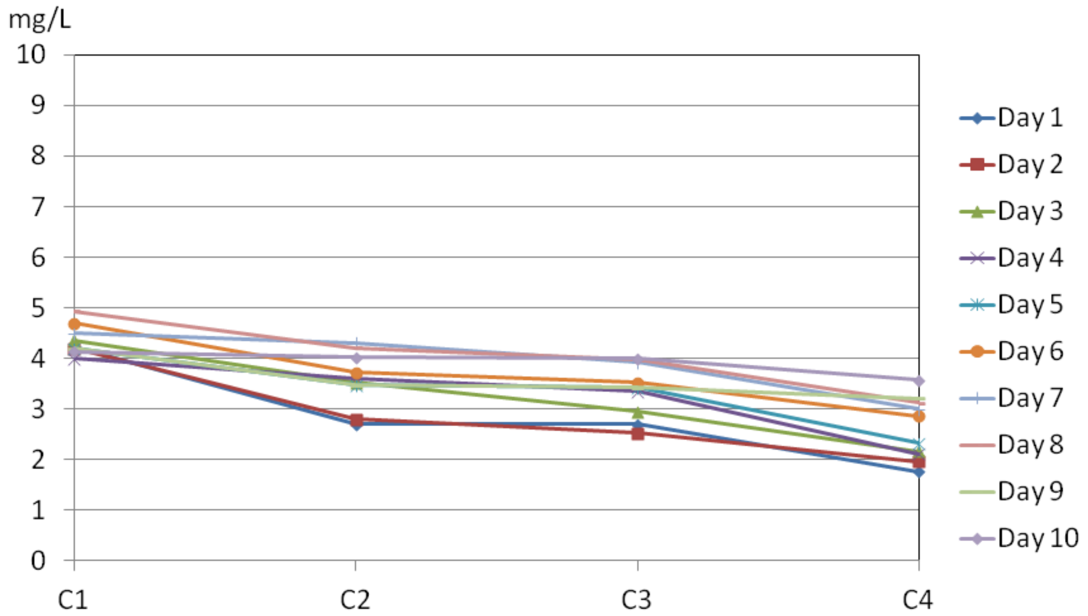


Figure 10: Nitrate Concentration for Reactor 1

Nitrate concentration for reactor 1 at day 1 is the lowest which means the plant uptake is the highest with concentration 4.23 mg/L at sampling point C1 and began to decrease to 2.70 mg/L for both sampling points C2 and C3, and finally 1.77 mg/L at sampling point C4. The concentration of nitrate began to increase throughout the sampling days and it shows that the plant began to acclimatised with the wastewater effluent as the uptake is no longer absorb the nitrate as much as during day 1. At day 5, the concentration at C1 is 4.20 mg/L and 2.33 mg/L at C4. At the end of sampling days, the concentration of nitrate does not change much. The concentration at C1 is 4.13 mg/L, 4.03 mg/L at C2, 4.00 mg/L at C3 and 3.57 mg/L at C4.

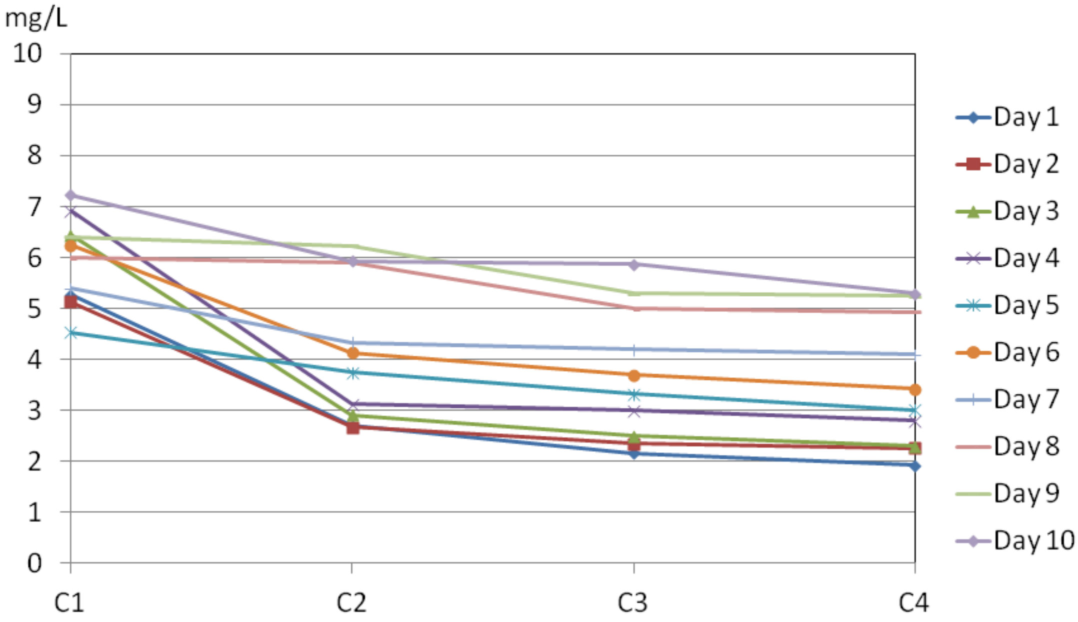


Figure 11: Nitrate Concentration for Reactor 2

Nitrate concentration for reactor 2 is slightly higher than reactor 1. This is because sludge is used together with soil in this reactor. At the beginning of the sampling days, the concentration of nitrate at sampling point C1 is 5.27 mg/L and decrease to 1.93 mg/L at the end of sampling point. The concentration of nitrate began to increase throughout the sampling days and it shows that the plant began to acclimatised with the wastewater effluent as the uptake is no longer absorb the nitrate as much as during day 1. At day 5, the concentration of nitrate at C1 is 4.53 mg/L and 3.01 mg/L at C4. At the end of sampling days, the concentration of nitrate does not change much. The concentration at C1 is 7.23 mg/L, 5.93 mg/L at C2, 5.87 mg/L at C3 and 5.30 mg/L at C4.

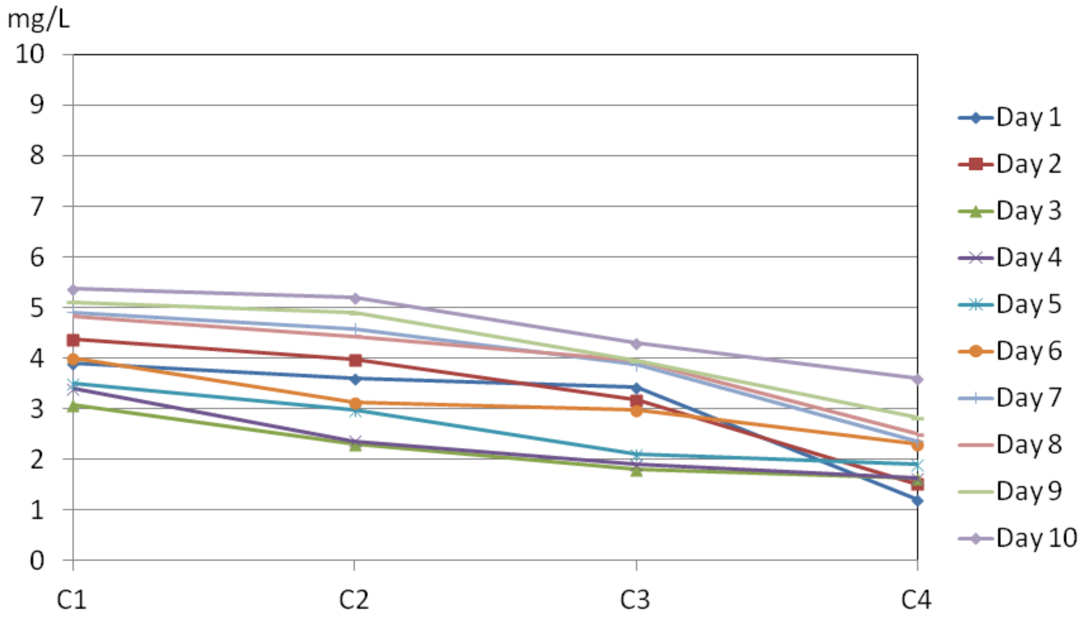


Figure 12: Nitrate Concentration for Reactor 3

For reactor 3 and reactor 4, the graphs do not show much different pattern compared to the first and second reactors. Nitrate concentration at the beginning of the sampling days, is 3.90 mg/L and decrease to 1.20 mg/L at the end of sampling point. The concentration of nitrate began to increase throughout the sampling days and it shows that the plant began to acclimatised with the wastewater effluent as the uptake is no longer absorb the nitrate as much as during day 1. At day 5, the concentration of nitrate at C1 is 3.50 mg/L and 1.90 mg/L at C4. At the end of sampling days, the concentration of nitrate does not change much. The concentration at C1 is 5.37 mg/L, 5.20 mg/L at C2, 4.30 mg/L at C3 and 3.60 mg/L at C4.

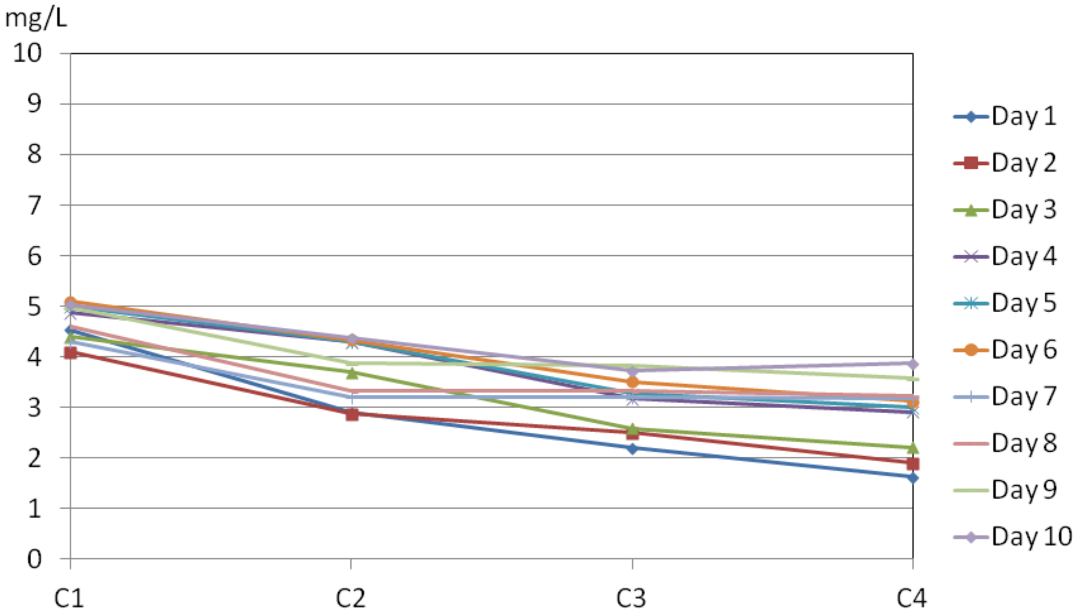


Figure 13: Nitrate Concentration for Reactor 4

For reactor 4, nitrate concentration at the beginning of the sampling days, is 5.43 mg/L and decrease to 1.63 mg/L at the end of sampling point. The concentration of nitrate began to increase throughout the sampling days and it shows that the plant began to acclimatised with the wastewater effluent as the uptake is no longer absorb the nitrate as much as during day 1. At day 5, the concentration of nitrate at C1 is 5.00 mg/L and 3.00 mg/L at C4. At the end of sampling days, the concentration of nitrate does not change much. The concentration at C1 is 5.03 mg/L, 4.37 mg/L at C2, 3.73 mg/L at C3 and 3.87 mg/L at C4.

## 2. Ammonia

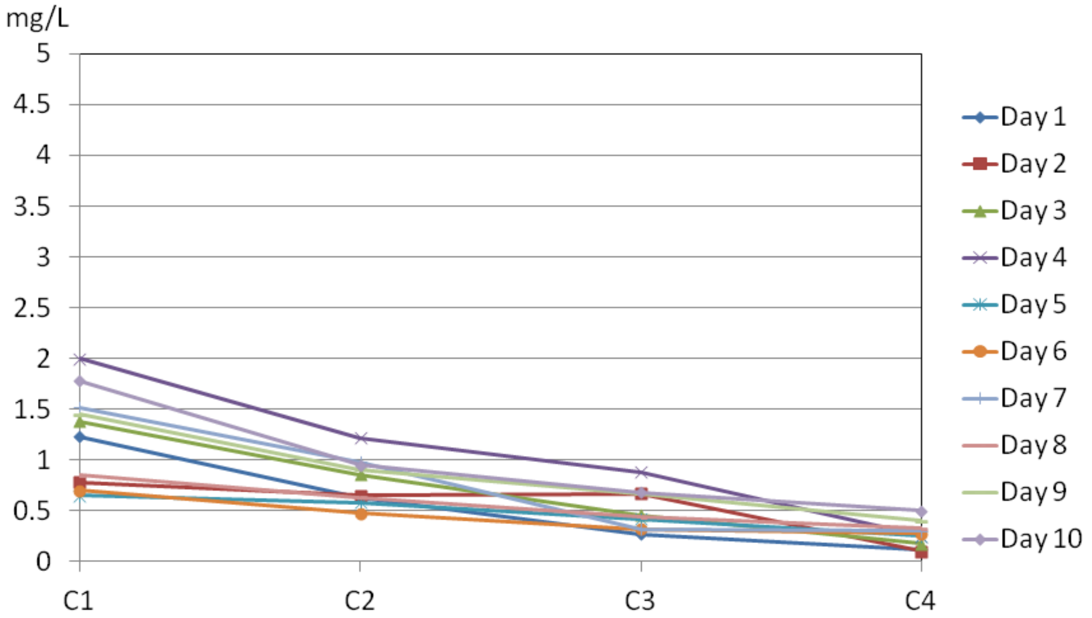


Figure 14: Ammonia Concentration for Reactor 1

For reactor 1 that contained 100% soils, ammonia concentration on the first sampling day at sampling point C1 is 1.23 mg/L. The concentration decreased along the sampling points with the value 0.63 mg/L for C2, 0.27 mg/L for C3 and 0.12 mg/L for C4. On the fifth day, the concentration began to increase with the value 0.65 mg/L for C1, 0.58 mg/L for C2, 0.42 mg/L for C3 and 0.25 mg/L for C4. The concentration of ammonia began to increase throughout the sampling days and it shows that the plant began to acclimatised with the wastewater effluent as the uptake is no longer absorb the ammonia as much as during day 1. At the end of sampling days, the concentration of ammonia does not change much among the sampling points. The concentration at C1 is 1.78 mg/L, 0.95 mg/L at C2, 0.68 mg/L at C3 and 0.50 mg/L at C4. Ammonia concentrations for all reactors are lower than nitrate concentrations. This might due to the nitrification process that occurred throughout the experiment as the reactors are being exposed to the air.

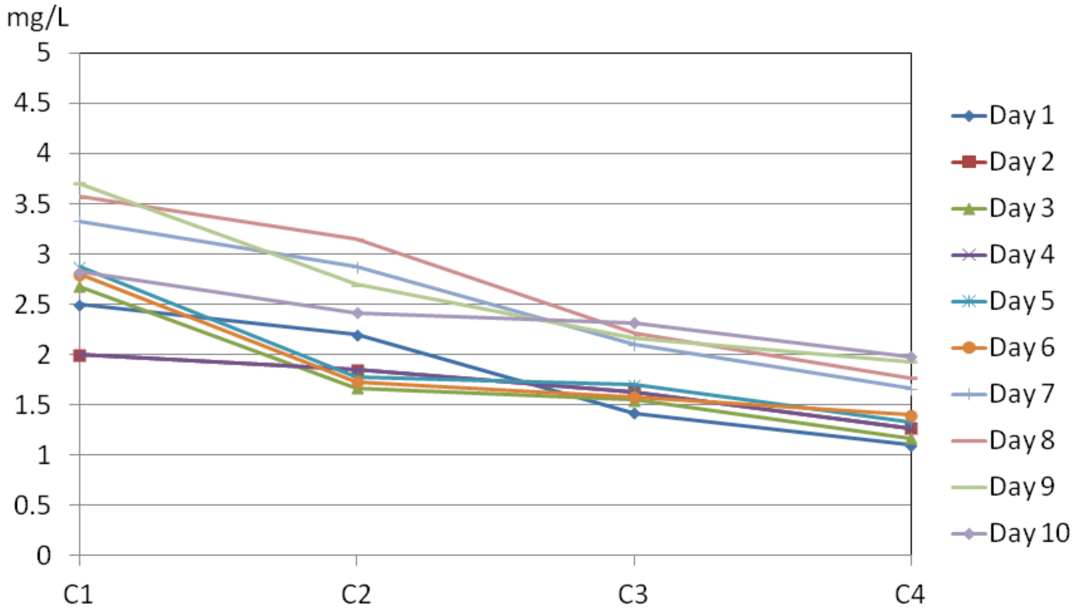


Figure 15: Ammonia Concentration for Reactor 2

Same with nitrate concentration, ammonia concentration for reactor 2 is slightly higher compared to the first reactor due to the usage of sludge with the soil. On the first sampling day, the concentration at sampling point C1 is 2.50 mg/L. The concentration decreased along the sampling points with the value 2.20 mg/L for C2, 1.42 mg/L for C3 and 1.10 mg/L for C4. On the fifth day, the concentration began to increase with the value 2.87 mg/L for C1, 1.78 mg/L for C2, 1.70 mg/L for C3 and 1.33 mg/L for C4. The concentration of ammonia began to increase throughout the sampling days and it shows that the plant began to acclimatised with the wastewater effluent as the uptake is no longer absorb the ammonia as much as during day 1. At the end of sampling days, the concentration of ammonia does not change much among the sampling points. On the $10^{th}$ day, the concentration at C1 is 2.82 mg/L, 2.42 mg/L at C2, 2.32 mg/L at C3 and 1.98 mg/L at C4.

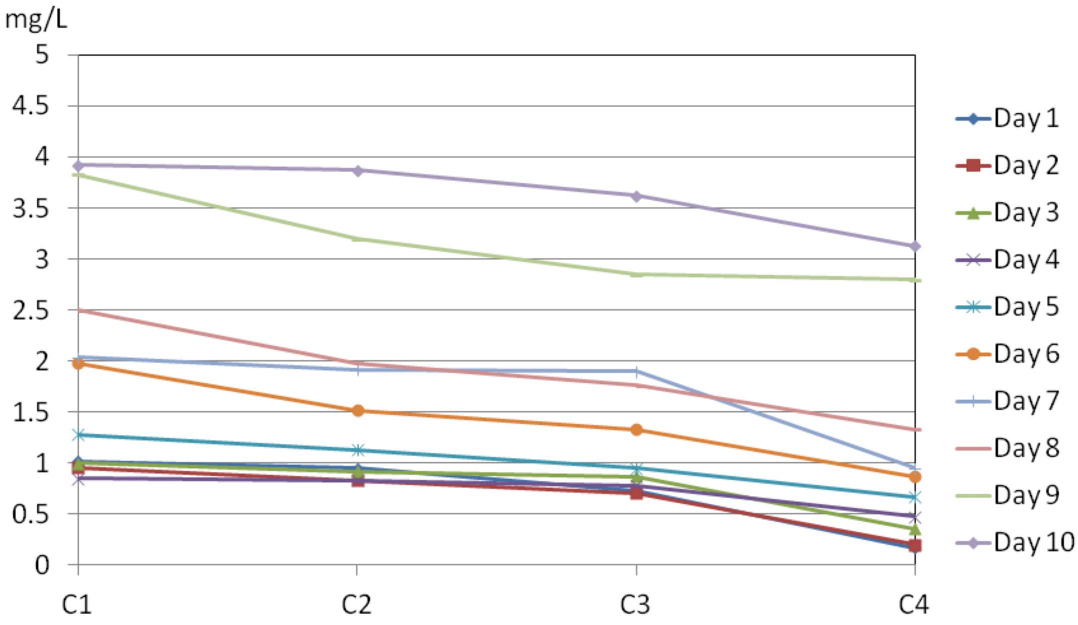


Figure 16: Ammonia Concentration for Reactor 3

For reactor 3, the concentration of ammonia on the first sampling day at sampling point C1 is 1.02 mg/L. The concentration decreased along the sampling points with the value 0.95 mg/L for C2, 0.73 mg/L for C3 and 0.17 mg/L for C4. On the fifth day, the concentration began to increase with the value 1.28 mg/L for C1, 1.13 mg/L for C2, 0.95 mg/L for C3 and 0.67 mg/L for C4. The concentration of ammonia began to increase throughout the sampling days and it shows that the plant began to acclimatised with the wastewater effluent as the uptake is no longer absorb the ammonia as much as during day 1. At the end of sampling days, the concentration of ammonia does not change much among the sampling points. On the $10^{th}$ day, the concentration at C1 is 3.92 mg/L, 3.87 mg/L at C2, 3.62 mg/L at C3 and 3.13 mg/L at C4. The concentration of ammonia in this reactor is a bit high compared to the fourth reactor. The plant used for this reactor might not suitable to be used for phytoremediation because the uptake of the ammonia is little.

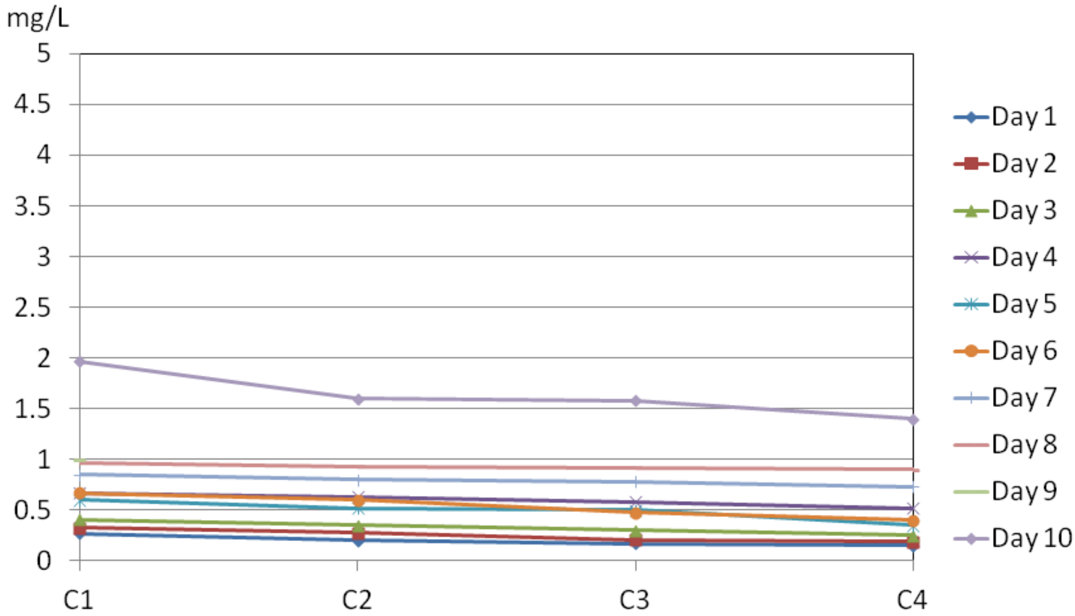


Figure 17: Ammonia Concentration for Reactor 4

For reactor 4, the concentration of ammonia on the first sampling day at sampling point C1 is 0.27 mg/L. The concentration decreased along the sampling points with the value 0.20 mg/L for C2, 0.17 mg/L for C3 and 0.15 mg/L for C4. On the fifth day, the concentration began to increase with the value 0.60 mg/L for C1, 0.52 mg/L for C2, 0.50 mg/L for C3 and 0.35 mg/L for C4. The concentration of ammonia began to increase throughout the sampling days and it shows that the plant began to acclimatised with the wastewater effluent as the uptake is no longer absorb the ammonia as much as during day 1. At the end of sampling days, the concentration of ammonia does not change much among the sampling points. On the $10^{th}$ day, the concentration at C1 is 1.97 mg/L, 1.60 mg/L at C2, 1.58 mg/L at C3 and 1.40 mg/L at C4. Sudden increase in the concentration of ammonia might due to the waste water effluent that has high concentration of ammonia.

### 3. Phosphorus

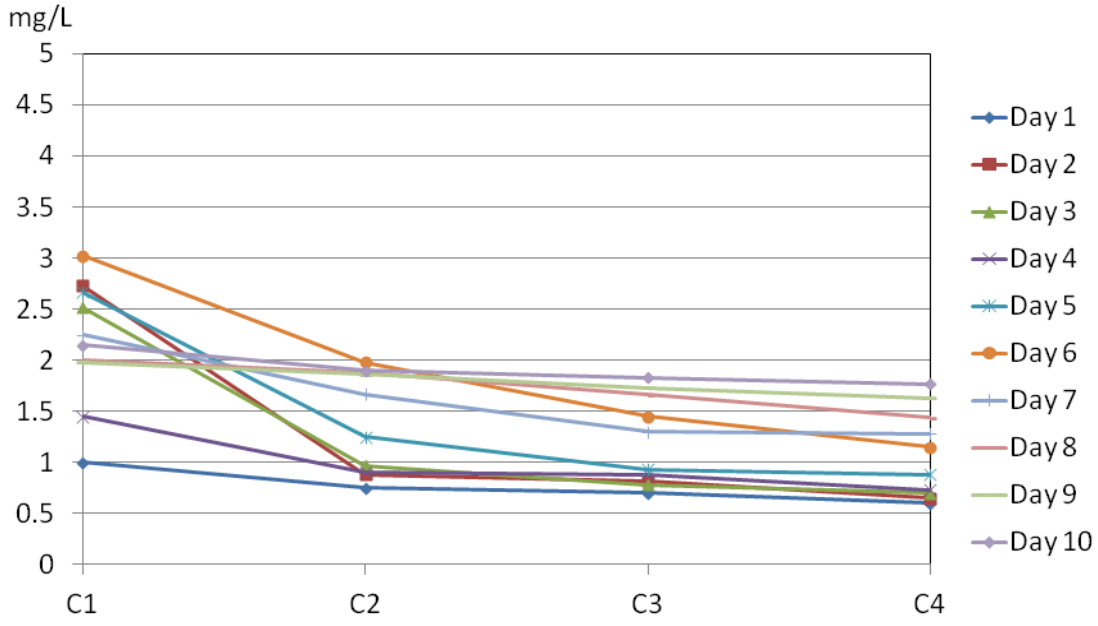


Figure 18: Phosphorus Concentration for Reactor 1

Phosphorus concentration for reactor 1 on day 1 is the lowest which means the plant uptake is the highest with concentration 1.00 mg/L at sampling point C1 and began to decrease to 0.75 mg/L for C2, 0.70 mg/L at C3, and finally 0.60 mg/L at sampling point C4. The concentration of phosphorus began to increase throughout the sampling days and it shows that the plant began to acclimatised with the wastewater effluent as the uptake is no longer absorb the phosphorus as much as during day 1. At day 5, the concentration at C1 is 2.67 mg/L and 0.88 mg/L at C4. At the end of sampling days, the concentration of phosphorus does not change much. The concentration at C1 is 2.15 mg/L, 1.90 mg/L at C2, 1.83 mg/L at C3 and 1.77 mg/L at C4.

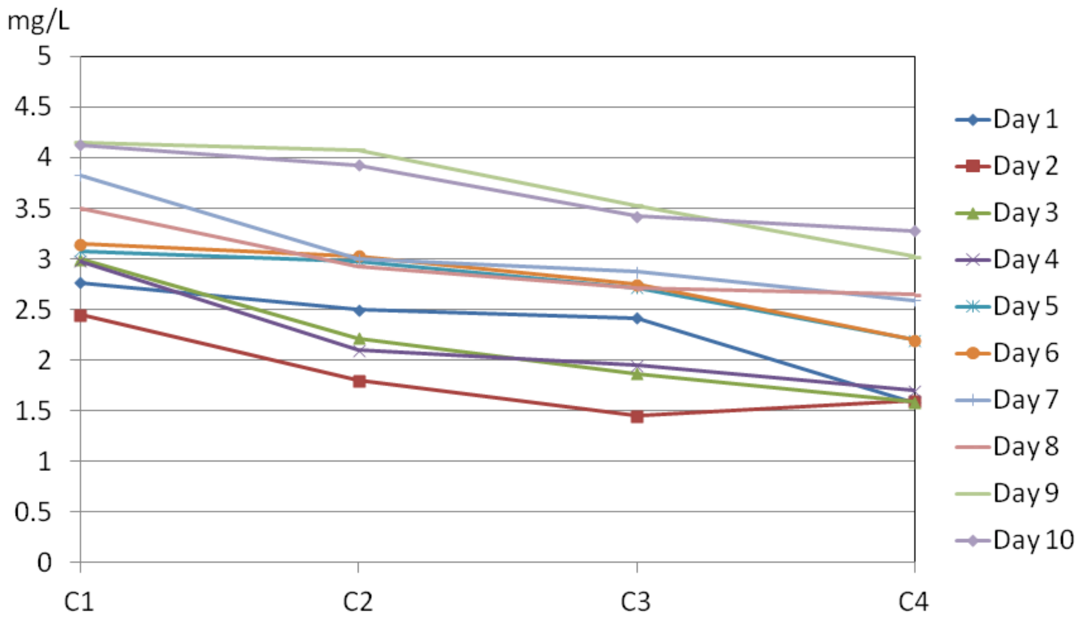


Figure 19: Phosphorus Concentration for Reactor 2

Phosphorus concentration for reactor 2 is slightly higher than reactor 1. This is because sludge is used together with soil in this reactor. At the beginning of the sampling days, the concentration of phosphorus at sampling point C1 is 2.77 mg/L and decrease to 1.58 mg/L at the end of sampling point. The concentration of phosphorus began to increase throughout the sampling days and it shows that the plant began to acclimatised with the wastewater effluent as the uptake is no longer absorb the phosphorus as much as during day 1. At day 5, the concentration of phosphorus at C1 is 3.08 mg/L and 2.20 mg/L at C4. At the end of sampling days, the concentration of phosphorus does not change much throughout the sampling points. The concentration at C1 is 4.13 mg/L, 3.93 mg/L at C2, 3.42 mg/L at C3 and 3.28 mg/L at C4.

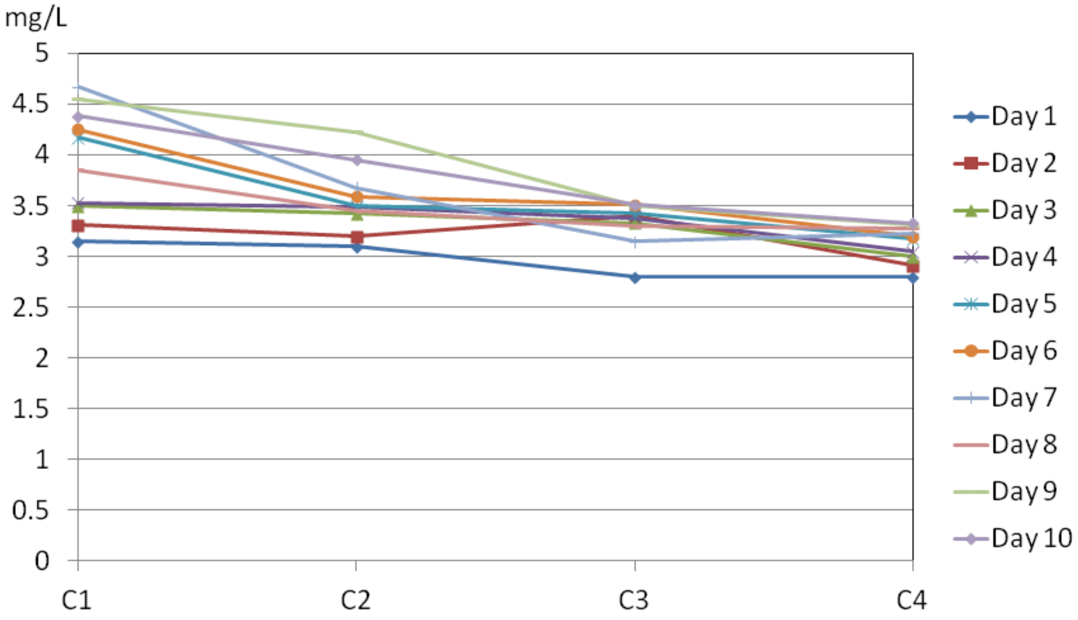


Figure 20: Phosphorus Concentration for Reactor 3

For reactor 3, the concentration of phosphorus on the first sampling day at sampling point C1 is 3.15 mg/L. The concentration decreased along the sampling points with the value 3.10 mg/L for C2, 2.80 mg/L for both C3 and C4. On the fifth day, the concentration began to increase with the value 4.17 mg/L for C1, 3.50 mg/L for C2, 3.42 mg/L for C3 and 3.17 mg/L for C4. The concentration of phosphorus began to increase throughout the sampling days and it shows that the plant began to acclimatised with the wastewater effluent as the uptake is no longer absorb the phosphorus as much as during day 1. At the end of sampling days, the concentration of phosphorus does not change much among the sampling points. On the 10$^{th}$ day, the concentration at C1 is 4.38 mg/L, 3.95 mg/L at C2, 3.51 mg/L at C3 and 3.33 mg/L at C4.

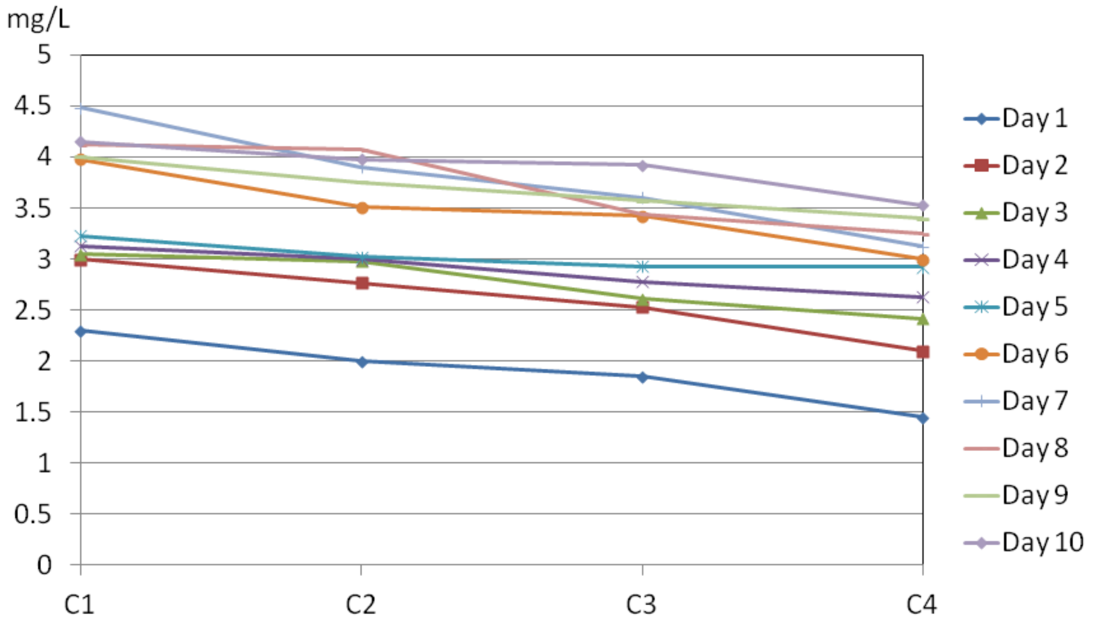


Figure 21: Phosphorus Concentration for Reactor 4

For reactor 4, phosphorus concentration at the beginning of the sampling days, is 2.30 mg/L and decrease to 1.45 mg/L at the end of sampling point. The concentration of phosphorus began to increase throughout the sampling days and it shows that the plant began to acclimatised with the wastewater effluent as the uptake is no longer absorb the phosphorus as much as during day 1. At day 5, the concentration of phosphorus at C1 is 3.23 mg/L and 2.92 mg/L at C4. At the end of sampling days, the concentration of nitrate does not change much. The concentration at C1 is 4.15 mg/L, 3.98 mg/L at C2, 3.92 mg/L at C3 and 3.53 mg/L at C4.

## 4. COD

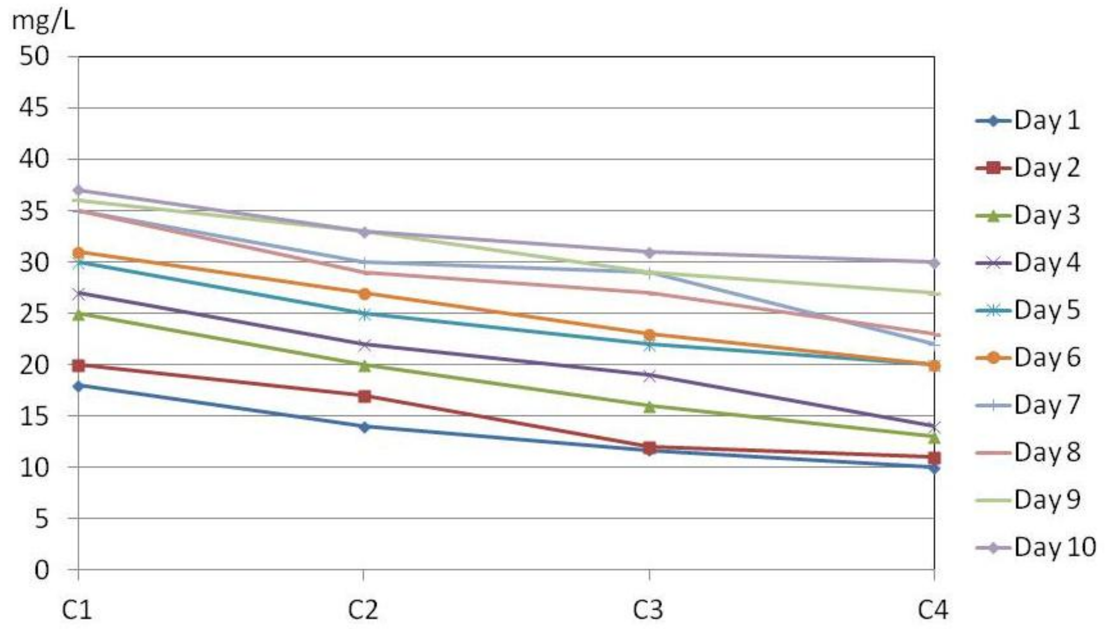


Figure 22: COD Value for Reactor 1

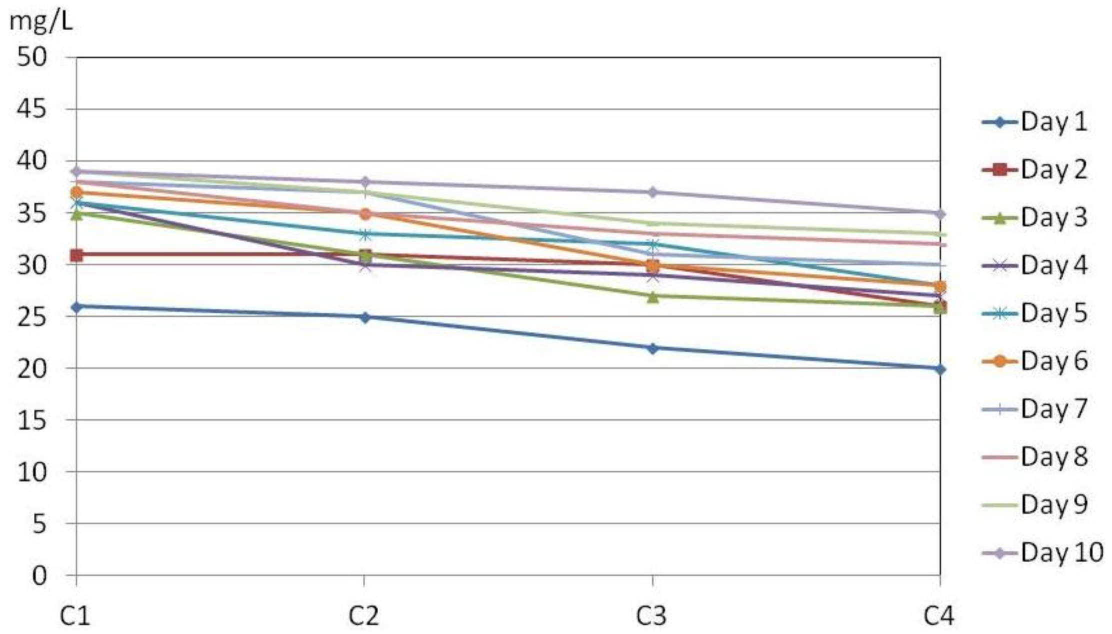


Figure 23: COD Value for Reactor 2

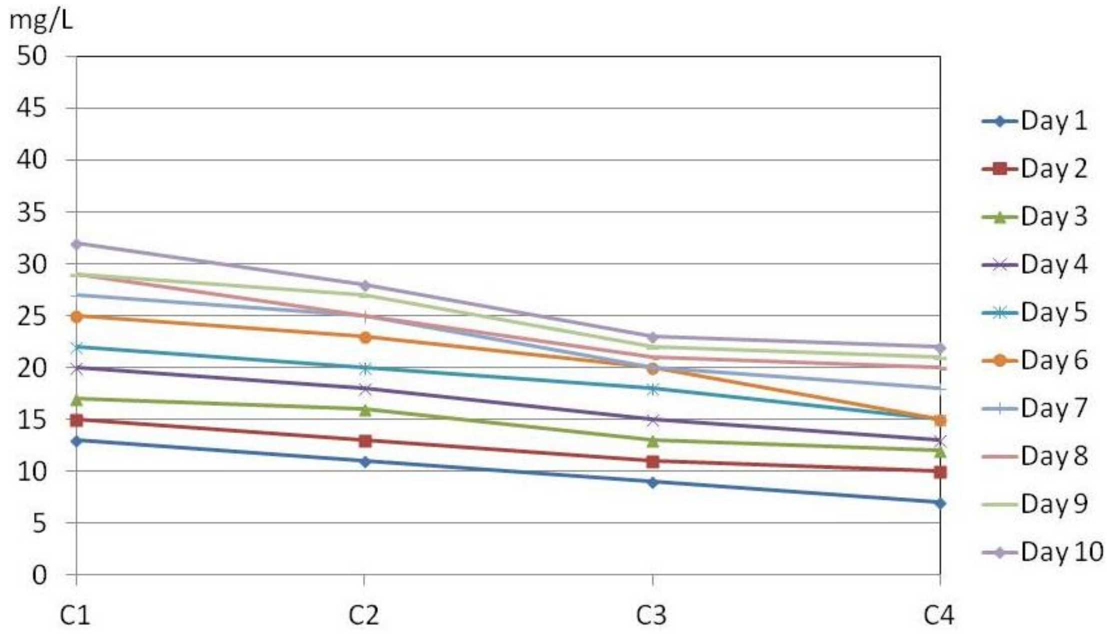


Figure 24: COD Value for Reactor 3

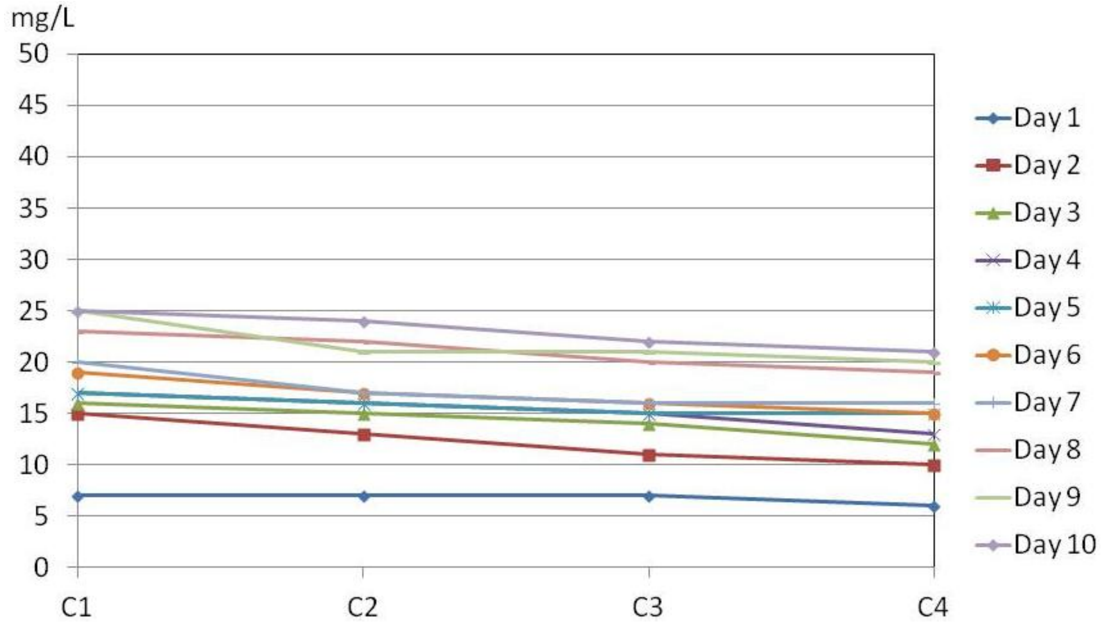


Figure 25: COD Value for Reactor 4

From the graphs in the previous pages, it is found out that the COD value in all four reactors increased along the sampling points. For reactor 1, the value on the first day at sampling point C1 is 10.0 mg/L and increased up to 18 mg/L at sampling point C4. At the end of the sampling days, the COD value increased to 30.0 mg/L at sampling point C1 and 37.0 mg/L at sampling point C4.

Reactor 2 has higher COD value with 20.0mg/L at C1 and 26.0 mg/L at C4 for the first day. The value increased to 35.0 mg/L at C1 and 39.0 mg/L at C4 for the last sampling day. The usage of sludge might influence this value because sludge contains nutrients as well as organic matter that caused COD value to be higher.

Reactor 3 and reactor 4 have almost the same COD value throughout the research. For the third reactor, the value at C1 is 7.0 mg/L and 13.0 mg/L at C4 for the first sampling days. The value increased to 22.0 mg/L at C1 and 32 mg/L at C4 on the $10^{th}$ day. Meanwhile for reactor 4, the value at C1 is 6.0 mg/L and 7.0 mg/L at C4 for the first sampling days. The value increased to 21.0 mg/L at C1 and 25.0 mg/L at C4 on the final day.

The concentration of COD at the end of sampling point is acceptable as it is still under the Standard A limit which is 50.0 mg/L**.**

### 5. Plant's Growth Observation

| | Reactor 1 | | | | | | | | | | Reactor 2 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Compartment 1 | - | - | - | - | S | S | S | S | F | F | - | - | S | S | S | S | F | F | F | F |
| Compartment 2 | - | - | - | - | - | - | S | S | S | S | - | - | S | S | S | S | S | S | S | S |
| Compartment 3 | - | - | - | - | - | - | S | S | S | S | - | - | S | S | S | S | S | S | S | S |
| Compartment 4 | - | - | - | - | S | S | S | S | F | F | - | - | S | S | S | S | F | F | F | F |

| | Reactor 3 | | | | | | | | | | Reactor 4 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Compartment 1 | - | - | S | S | S | S | S | S | S | F | - | - | - | S | S | S | S | S | S | S |
| Compartment 2 | - | - | S | S | S | S | S | S | S | S | - | - | - | S | S | S | S | S | S | S |
| Compartment 3 | - | - | S | S | S | S | S | S | S | S | - | - | - | S | S | S | S | S | S | S |
| Compartment 4 | - | - | S | S | S | S | S | F | F | F | - | - | - | S | S | S | S | S | S | S |

| | | | |
|---|---|---|---|
| New young shoot | S | Flowering | F |

Table 3: Plant's Growth Observation

Throughout the research, it is found out that the plants in reactor 2 growths very well. In 3 days after the plants were planted, new young shoot has developed. In 7 days, the plants started to produce flower. Compared to reactor 1, the plants in reactor 1 start to produce new young shoot after five to six days it were planted. For flowering plant in compartment 1 and 4, it starts to produce flower on the ninth day.

Figure 26: Plants Comparison between Reactor 1 and  Reactor 2

Plants in reactor 3 and reactor 4 grow very well where it starts to develop new young in day 3 and day 4. For reactor 3, as water lily plants were being used, the plants start to produce flower in day 10 in the first compartment and day 7 in compartment 4.

Figure 27: Water Lily's Flower

New young shoot started to develop in day 3 for water lettuce plant in reactor 4. In 10 days, there are about 16 new plants were produced in each compartment.

# CHAPTER 5

# CONCLUSION

The activities during Final Year Project (FYP) 1 have been carried out successfully within the specified time frame. From FYP 1, the author was exposed to the project by doing some researches and studies in order to get full understanding regarding the project and this knowledge will be used for Final Year Project 2.

Final FYP 2 started by fabrication of reactors and planting landscape plants in the reactors. The effluent from sewage treatment plant is tapped to the reactors and after one day detention time, the sampling is done. 4 experiments are being carried to identify the removal efficiency of landscape plants in removal nutrients (nitrate, phosphorus and ammonia) and the COD value is measured. The growth of the plants is being observed during this stage by observing new young shoot development.

Throughout the research, it is found out that the nutrients are reduced throughout the sampling points of the reactors. However, zero-discharged is not yet achieved as there are still some nutrients at the final sampling point. From the research, it is found out that landscape plants as well as water plants can be used for phytoremediation. It is not only absorbing the nutrients but it can also beautify our surrounding.

Usage of sludge caused the nutrients concentration in the water sample higher. However, as sludge also act as fertilizer, the plants in the second reactor growth better than in the first reactor. Modification needs to be done for reactor 1 and reactor 2 because the water level is too high and may caused plants died.

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# APPENDICES

1. Research Site's Pictures:

Figure 28: Reactors after Fabrication


Figure 27 (i)    Figure 27 (ii)


Figure 27 (iii)    Figure 27 (iv)

Figure 29 (i, ii, iii & iv): Preparation for Planting

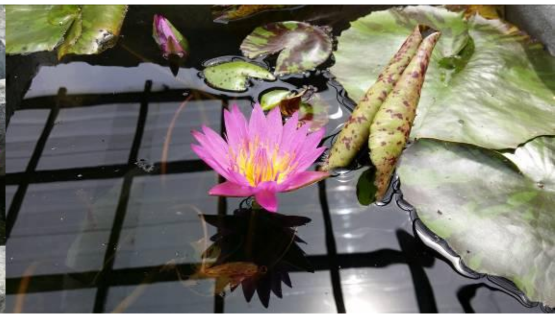

Figure 28 (ii) Figure 28 (ii)

Figure 30 (i & ii): Plants Observation


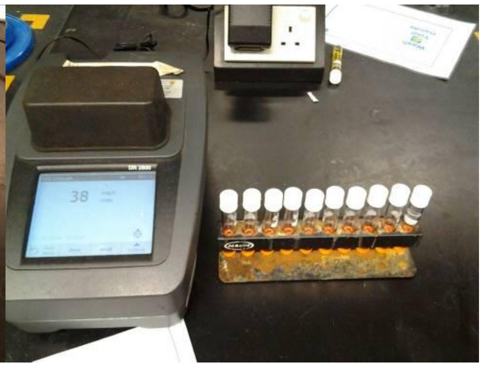


Figure 29 (i) Figure 29 (ii)

Figure 31 (i, ii): Measurement of Parameters

2. Results from the experiment:

**Nitrate Concentration (mg/L)**

Reactor 1

| Sampling Point | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 4.23 | 4.2 | 4.36 | 4 | 4.2 | 4.7 | 4.5 | 4.93 | 4.2 | 4.13 |
| **C2** | 2.7 | 2.8 | 3.53 | 3.61 | 3.47 | 3.73 | 4.31 | 4.21 | 3.47 | 4.03 |
| **C3** | 2.7 | 2.53 | 2.95 | 3.35 | 3.43 | 3.53 | 3.93 | 3.98 | 3.43 | 4 |
| **C4** | 1.77 | 1.97 | 2.16 | 2.12 | 2.33 | 2.86 | 3 | 3.13 | 3.21 | 3.57 |

Reactor 2

| Sampling Point | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 5.27 | 5.13 | 6.44 | 6.92 | 4.53 | 6.25 | 5.4 | 6 | 6.41 | 7.23 |
| **C2** | 2.7 | 2.67 | 2.91 | 3.13 | 3.75 | 4.14 | 4.33 | 5.91 | 6.23 | 5.93 |
| **C3** | 2.17 | 2.35 | 2.5 | 3 | 3.33 | 3.7 | 4.2 | 5 | 5.3 | 5.87 |
| **C4** | 1.93 | 2.27 | 2.3 | 2.8 | 3.01 | 3.43 | 4.1 | 4.93 | 5.25 | 5.3 |

Reactor 3

| Sampling Point | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 3.9 | 4.37 | 3.07 | 3.4 | 3.5 | 4 | 4.91 | 4.83 | 5.11 | 5.37 |
| **C2** | 3.6 | 3.97 | 2.3 | 2.37 | 2.98 | 3.13 | 4.59 | 4.44 | 4.9 | 5.2 |
| **C3** | 3.43 | 3.17 | 1.8 | 1.9 | 2.1 | 2.98 | 3.87 | 3.95 | 3.95 | 4.3 |
| **C4** | 1.2 | 1.52 | 1.63 | 1.63 | 1.9 | 2.3 | 2.37 | 2.5 | 2.83 | 3.6 |

Reactor 4

| Sampling Point | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 4.53 | 4.1 | 4.4 | 4.87 | 5 | 5.1 | 4.3 | 4.6 | 4.97 | 5.03 |
| **C2** | 2.9 | 2.87 | 3.7 | 4.3 | 4.3 | 4.33 | 3.2 | 3.33 | 3.87 | 4.37 |
| **C3** | 2.2 | 2.5 | 2.59 | 3.17 | 3.27 | 3.51 | 3.2 | 3.33 | 3.83 | 3.73 |
| **C4** | 1.63 | 1.9 | 2.22 | 2.91 | 3 | 3.13 | 3.17 | 3.23 | 3.57 | 3.87 |

**Ammonia Concentration (mg/L)**

Reactor 1

| Sampling Point | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 1.23 | 0.78 | 1.38 | 2 | 0.65 | 0.7 | 1.52 | 0.85 | 1.45 | 1.78 |
| **C2** | 0.63 | 0.65 | 0.86 | 1.22 | 0.583 | 0.48 | 0.98 | 0.63 | 0.91 | 0.95 |
| **C3** | 0.27 | 0.67 | 0.46 | 0.88 | 0.42 | 0.32 | 0.32 | 0.44 | 0.67 | 0.68 |
| **C4** | 0.12 | 0.1 | 0.18 | 0.25 | 0.25 | 0.28 | 0.3 | 0.33 | 0.4 | 0.5 |

Reactor 2

| Sampling Point | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 2.5 | 2 | 2.68 | 2 | 2.87 | 2.8 | 3.33 | 3.57 | 3.7 | 2.82 |
| **C2** | 2.2 | 1.85 | 1.67 | 1.85 | 1.78 | 1.73 | 2.87 | 3.15 | 2.7 | 2.42 |
| **C3** | 1.42 | 1.63 | 1.55 | 1.63 | 1.7 | 1.58 | 2.1 | 2.21 | 2.17 | 2.32 |
| **C4** | 1.1 | 1.27 | 1.17 | 1.27 | 1.33 | 1.4 | 1.66 | 1.77 | 1.93 | 1.98 |

Reactor 3

| Sampling Point | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 1.02 | 0.96 | 1 | 0.85 | 1.28 | 1.98 | 2.04 | 2.5 | 3.83 | 3.92 |
| **C2** | 0.95 | 0.83 | 0.92 | 0.83 | 1.13 | 1.52 | 1.92 | 1.98 | 3.2 | 3.87 |
| **C3** | 0.73 | 0.71 | 0.87 | 0.78 | 0.95 | 1.33 | 1.9 | 1.76 | 2.85 | 3.62 |
| **C4** | 0.17 | 0.2 | 0.36 | 0.48 | 0.67 | 0.87 | 0.95 | 1.33 | 2.8 | 3.13 |

Reactor 4

| Sampling Point | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 0.27 | 0.33 | 0.41 | 0.54 | 0.6 | 0.67 | 0.67 | 0.85 | 0.97 | 1.97 |
| **C2** | 0.2 | 0.28 | 0.35 | 0.42 | 0.52 | 0.6 | 0.63 | 0.8 | 0.93 | 1.6 |
| **C3** | 0.17 | 0.21 | 0.3 | 0.33 | 0.5 | 0.48 | 0.58 | 0.78 | 0.92 | 1.58 |
| **C4** | 0.15 | 0.19 | 0.25 | 0.28 | 0.35 | 0.4 | 0.52 | 0.73 | 0.9 | 1.4 |

**Phosphorus Concentration (mg/L)**

Reactor 1

| Sampling Point | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 1 | 2.73 | 2.52 | 1.45 | 2.67 | 3.02 | 2.25 | 2 | 1.98 | 2.15 |
| **C2** | 0.75 | 0.88 | 0.97 | 0.91 | 1.25 | 1.98 | 1.67 | 1.88 | 1.86 | 1.9 |
| **C3** | 0.7 | 0.82 | 0.78 | 0.88 | 0.93 | 1.45 | 1.3 | 1.66 | 1.73 | 1.83 |
| **C4** | 0.6 | 0.65 | 0.7 | 0.73 | 0.88 | 1.15 | 1.28 | 1.44 | 1.63 | 1.77 |

Reactor 2

| Sampling Point | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 2.77 | 2.45 | 3 | 2.98 | 3.08 | 3.15 | 3.83 | 3.5 | 4.15 | 4.13 |
| **C2** | 2.5 | 1.8 | 2.22 | 2.1 | 2.98 | 3.03 | 3 | 2.93 | 4.08 | 3.93 |
| **C3** | 2.42 | 1.45 | 1.87 | 1.95 | 2.72 | 2.75 | 2.87 | 2.71 | 3.53 | 3.42 |
| **C4** | 1.58 | 1.6 | 1.59 | 1.7 | 2.2 | 2.2 | 2.59 | 2.65 | 3.02 | 3.28 |

Reactor 3

| Sampling Point | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 3.15 | 3.31 | 3.5 | 3.53 | 4.17 | 4.25 | 4.67 | 3.85 | 4.55 | 4.38 |
| **C2** | 3.1 | 3.2 | 3.42 | 3.49 | 3.5 | 3.59 | 3.68 | 3.45 | 4.23 | 3.95 |
| **C3** | 2.8 | 3.4 | 3.33 | 3.38 | 3.42 | 3.51 | 3.15 | 3.3 | 3.5 | 3.51 |
| **C4** | 2.8 | 2.91 | 3 | 3.05 | 3.17 | 3.2 | 3.23 | 3.28 | 3.31 | 3.33 |

Reactor 4

| Sampling Point | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 2.3 | 3 | 3.05 | 3.13 | 3.23 | 3.98 | 4.48 | 4.12 | 4 | 4.15 |
| **C2** | 2 | 2.77 | 2.98 | 3 | 3.02 | 3.51 | 3.9 | 4.07 | 3.75 | 3.98 |
| **C3** | 1.85 | 2.53 | 2.61 | 2.78 | 2.93 | 3.42 | 3.6 | 3.44 | 3.57 | 3.92 |
| **C4** | 1.45 | 2.1 | 2.42 | 2.63 | 2.92 | 3 | 3.12 | 3.25 | 3.4 | 3.53 |

**COD Value (mg/L)**

Reactor 1

| Sampling Point | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 18 | 20 | 25 | 27 | 30 | 31 | 35 | 35 | 36 | 37 |
| **C2** | 14 | 17 | 20 | 22 | 25 | 27 | 30 | 29 | 33 | 33 |
| **C3** | 11.67 | 12 | 16 | 19 | 22 | 23 | 29 | 27 | 29 | 31 |
| **C4** | 10 | 11 | 13 | 14 | 20 | 20 | 22 | 23 | 27 | 30 |

Reactor 2

| Sampling Point | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 26 | 31 | 35 | 36 | 36 | 37 | 38 | 38 | 39 | 39 |
| **C2** | 25 | 31 | 31 | 30 | 33 | 35 | 37 | 35 | 37 | 38 |
| **C3** | 22 | 30 | 27 | 29 | 32 | 30 | 31 | 33 | 34 | 37 |
| **C4** | 20 | 26 | 26 | 27 | 28 | 28 | 30 | 32 | 33 | 35 |

Reactor 3

| Sampling Point | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 13 | 15 | 17 | 20 | 22 | 25 | 27 | 29 | 29 | 32 |
| **C2** | 11 | 13 | 16 | 18 | 20 | 23 | 25 | 25 | 27 | 28 |
| **C3** | 9 | 11 | 13 | 15 | 18 | 20 | 20 | 21 | 22 | 23 |
| **C4** | 7 | 10 | 12 | 13 | 15 | 15 | 18 | 20 | 21 | 22 |

Reactor 4

| Sampling Point | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 7 | 15 | 16 | 17 | 17 | 19 | 20 | 23 | 25 | 25 |
| **C2** | 7 | 13 | 15 | 16 | 16 | 17 | 17 | 22 | 21 | 24 |
| **C3** | 7 | 11 | 14 | 15 | 15 | 16 | 16 | 20 | 21 | 22 |
| **C4** | 6 | 10 | 12 | 13 | 15 | 15 | 16 | 19 | 20 | 21 |