REMOVAL OF AMMONIACAL NITROGEN (NH_3-N), PHOSPHORUS (PO_4), CHEMICAL OXYGEN DEMAND (COD) AND TOTAL SUSPENDED SOLID (TSS) USING ANAEROBIC AND AEROBIC DEGRADATION OF PHARMACEUTICAL WASTEWATER

By

Wan Hariz Fadli bin Wan Shafie

FINAL PROJECT REPORT

Submitted to the Civil Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Civil Engineering)

Universiti Teknologi Petronas
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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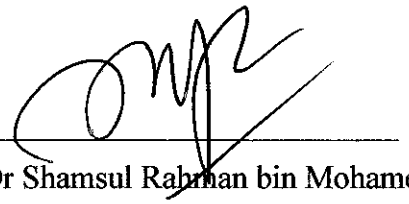
Approved:



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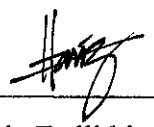
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

June 2007

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.



Wan Hariz Fadli bin Wan Shafie

ABSTRACT

The current treatment system of Safire Pharmaceuticals (M) Sdn. Bhd was not really effective and the operational cost of the wastewater treatment was high. The purpose of this project for the first phase was to investigate the removal efficiency of ammoniacal nitrogen (NH_3-N) and phosphorus (PO_4) from Safire's pharmaceutical wastewater using aerobic treatment. For the second phase, the project was executed to investigate the removal efficiency of total suspended solid (TSS) and chemical oxygen demand (COD) using anaerobic-aerobic treatment. The pharmaceutical wastewater was taken from a company which is Safire Pharmaceuticals (M) Sdn. Bhd located at Bandar Baru Seri Iskandar, near Universiti Teknologi PETRONAS. The wastewater influent and effluent samples were analyzed to determine the parameters such as influent and effluent of ammoniacal nitrogen (NH_3-N), phosphorus (PO_4), total suspended solid (TSS) and chemical oxygen demand (COD). For the first phase of aerobic treatment, two reactors had been used to treat the pharmaceutical wastewater. The difference between the reactors was sludge age. One of the reactors had been used short sludge age for the aerobic treatment and the other one we use long sludge age. Sludge age is a measure of the length of time a particle of suspended solids has been retained in the activated sludge process. For the second phase of the aerobic and anaerobic treatment, three reactors had been used to treat the pharmaceutical wastewater. One reactor used for anaerobic treatment and the other two were used for aerobic treatment. From the experiment at the first phase, the maximum percentage removal of the ammoniacal nitrogen (NH_3-N) quite high which was 54.3%. But, there was no change between the influent and effluent of phosphorus (PO_4) which means no removal of phosphorus using aerobic treatment. For the second phase, the maximum percentage removal of COD for pharmaceutical wastewater was 98.1% which quite high. Meanwhile, the maximum percentage removal of TSS for pharmaceutical wastewater was 46.8%. So, it can be concluded that the aerobic treatment could treat ammoniacal nitrogen (NH_3-N) but could not treat phosphorus (PO_4). However, the anaerobic-aerobic treatment could successfully treat both the chemical oxygen demand (COD) and total suspended solid (TSS).

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First of all thank God for the blessing that He gave to me. Without it I maybe can't make it through until now. From this opportunity, I would like to show my appreciation to people who had given contributions to me until the project finished successfully. Special thanks regard to my respective supervisor, Dr. Shamsul Rahman bin Mohamed Kutty who had guided, advised and gave encouragement to us in finishing this project. His contribution is valuable to my project and become a motivation to me to finish my project successfully on time. I will always remember his cooperation and contribution to my project. I would also like to send my regard to HSE Executive of Safire Pharmaceutical Sdn. Bhd , En. Ali who had consulted me about the project from the started until the project finished. Besides, special thanks and congratulation I regard to the members of my Final Year Project (FYP), Mohammad Hizam Shah and Mohd Nizad who had done a good job and helped me a lot in finishing this project successfully. All of the group members had shown a good team work and gave excellent cooperation in every aspect from beginning until we had finished constructing the project. The project would not finish successfully without their cooperation and contribution. Special thanks also to all laboratory demonstrators who had guided me during the laboratory session as a part of my project. Their guidance had made me easier to handle the laboratory works for the project. Finally, I would like to give special thanks to all people who had involved in my project and gave a lot of contribution directly or indirectly to me in order to finish my project. I hope my experience in doing project work can help me a lot in my future and I need this experience and skill to give contribution to human being.

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CHAPTER 1: INTRODUCTION

1.1 Background

The wastewater used in this project was collected with permission from Safire Pharmaceuticals (M) Sdn. Bhd., a pharmaceutical company which located at Bandar Baru Seri Iskandar, near Universiti Teknologi PETRONAS. This pharmaceutical company is established for manufacturing of generic drugs and contract manufacturing. The effluent of the pharmaceutical wastewater which has been assessed by the responsible person from the company has high organic and inorganic matter which exceeds the permitted value of Environmental Quality Act (EQA). The list of expected chemical in Safire's wastewater are Methanol, Ethanol, Sodium Chloride, Cleaning Agent (Decon 90), Sanitization Agent (Sodium Hypochloride), Sugar, Colorization Agent, Chloride Salt and Chlorine etc. The company produces pharmaceutical products like soaps, antibiotics, vitamins and so on.

1.2 Problem Statement

The current treatment system of Safire Pharmaceuticals (M) Sdn. Bhd was not really effective and the operational cost of the wastewater treatment was high. The company asked for proposal to set up their treatment systems in order to reduce the organic and inorganic matter level of the treated effluent.

1.3 Objectives and Scope of Study

The objective of this study is to determine the feasibility of treating Safire's pharmaceutical wastewater using aerobic treatment. The main purpose of this project is to find the effective solution for removal of ammoniacal nitrogen (NH_3-N) and phosphorus (PO_4). There were two phases conducted in this project. For the first phase, the treatment purpose of this project was to investigate the removal efficiency of ammoniacal nitrogen (NH_3-N) and phosphorus (PO_4) from Safire's pharmaceutical wastewater using aerobic treatment. For the second phase, the treatment purpose of this project was to investigate the removal efficiency of chemical oxygen demand (COD) and total suspended solid (TSS) using anaerobic-aerobic treatment. The influent and effluent concentration of all parameters had been determined from the experiment that conducted in environmental laboratory.

CHAPTER 2: LITERATURE REVIEW / THEORY

2.1 Anaerobic Treatment

A widely variety of wastewaters have been treated by anaerobic process including pharmaceuticals, landfill leachate, pulp and paper, soft drink beverages and so on. Anaerobic processes are attractive, especially for high strength and warm temperature wastewaters because aeration is not required, thus saving energy cost. Besides, low amount of solids generated from the anaerobic process. Other considerations that may apply to different wastewater sources are the presence of potential toxic streams, flow variations, inorganic concentrations, and seasonal load variations. Anaerobic processes are capable of responding quickly to wastewater feed after long periods without substrate addition. In some cases with warmer climates, anaerobic treatment has also been considered for municipal wastewater treatment. The project is just using aerobic treatment. This is the modification of this project.

2.1.1 Pharmaceutical Wastewater Treatment Using an Anaerobic/Aerobic Sequencing Batch Biofilter

The performance of a sequencing batch biofilter integrating anaerobic/aerobic conditions in one tank to treat a pharmaceutical wastewater effluent was studied. A pilot reactor, packed with a porous volcanic stone (puzzolane) was used in the study. The reactor operated as a sequencing batch biofilter, SBB, with reaction times varying for the anaerobic stage from 8 to 24 h and for the aerobic one from 4 to 12 h. The volume of exchange was from 16 to 88%. The pharmaceutical wastewater contained organic chemicals including phenols and o-nitroaniline, a concentration of organic matter that varied from 28,400 to 72,200 mg/L (as total COD), 280 to 605 mg N-NH_4/L, and 430 to 650 mg SST/L. In order to acclimatize the microorganisms to the industrial wastewater, the organic load was increased stepwise from 1 to 7.7 kg COD/m^3/d. The adequate time was obtained when the removal efficiency of COD reached 80% or more. Maximal removal loads, associated to high removal efficiencies (95–97% as COD), varied from

4.6 to 5.7 kg COD/m ^{3}/d. Under these conditions color removal was 80% as Pt-Co units. Microtox analysis was performed to the wastewater and to the anaerobic and aerobic stages. It was observed that the aerobic stage was the responsible for wastewater detoxification. Results showed that the anaerobic/aerobic SBB was able to treat efficiently initial concentrations of the raw effluent up to 28,400 mg COD/L.

2.2 Aerobic Treatment

The basic aerobic treatment process involves providing a suitable oxygen rich environment for organisms that can reduce the organic portion of the waste into carbon dioxide and water in the presence of oxygen. The removal of biological oxygen demand (BOD) can be accomplished in a number of anaerobic suspended growths or attached (fixed film) growth treatment process. Both require sufficient contact time between the wastewater and heterotrophic microorganisms, and sufficient oxygen and nutrients. During the initial biological uptake of the organic material, more than half of it is oxidized and the remainder is assimilated as new biomass, which may be further oxidized by endogenous respiration. The bacteria growth in the sludge can be used for the aerobic treatment process because the bacteria can digest the organic materials.

2.2.1 Aerobic biological treatment of a pharmaceutical wastewater: effect of temperature on cod removal and bacterial community development.

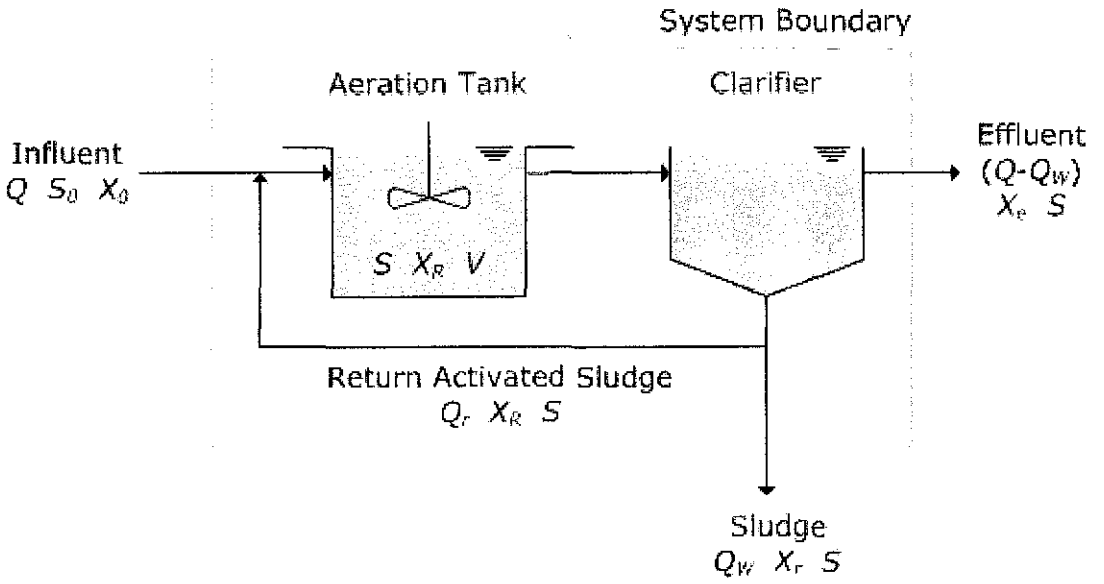
The effect of temperature was studied on the efficiency of soluble COD removal and bacterial community development during the aerobic biological treatment of a pharmaceutical wastewater. Using wastewater and bacterial inoculum obtained from the full-scale facility treating this wastewater, batch laboratory cultures were operated at 5 degrees C intervals from 30 degrees C to 70 C. Following four culture transfers to allow for bacterial acclimation, residual soluble COD levels were measured and bacterial

community fingerprints were obtained by denaturing gradient gel electrophoresis (DGGE) of polymerase chain reaction (PCR)-amplified 16S rRNA gene fragments. Soluble COD removal efficiency declined as temperature increased from 30 degrees C (62%) to 60 degrees C (38%). Biological treatment of this wastewater failed to occur at temperatures higher than 60 C. Gradual shifts in bacterial community structure were detected as temperature increased, including a concomitant reduction in the number of different bacterial populations. The impact of temperature on a two-stage biological treatment process was also compared. Better soluble COD removal was achieved when both reactors were operated at 30 degrees C compared to a system where the two stages were consecutively operated at 55 degrees C and 30 degrees C. These results indicate that operation of aerobic biological wastewater treatment reactors at elevated temperatures can have adverse effects on process performance.

2.3 Activated sludge system

The activated sludge process is a wastewater treatment method in which the carbonaceous organic matter of wastewater provides an energy source for the production of new cells for a mixed population of microorganisms in an aquatic aerobic environment. In the activated sludge, there are presence of biological component consists of microorganisms. These microorganisms comprised of 70 to 90 percent organic matter and 10 to 30 percent inorganic matter. Further, the chemical composition of the wastewater and the specific characteristics of the organisms in the biological community are important factors that lead to the cell composition.

The overall goal of the activated-sludge process is to remove substances that have a demand for oxygen from the system. This is accomplished by the metabolic reactions (synthesis-respiration and nitrificaction) of the microorganisms, the separation and settling of activated-sludge solids to create an acceptable quality of secondary wastewater effluent, and the collection and recycling of microorganisms back into the system or removal of excess microorganisms from system.



Where:

Q = flowrate of influent	[m^3/d]
Q_W = waste sludge flowrate	[m^3/d]
Q_r = flowrate in return line from clarifier	[m^3/d]
V = volume of aeration tank	[m^3]
S_0 = influent soluble substrate concentration (bsCOD)	[BOD g/m^3] or [bsCOD g/m^3]
S = effluent soluble substrate concentration (bsCOD)	[BOD g/m^3] or [bsCOD g/m^3]
X_0 = concentration of biomass in influent	[g VSS/m^3]
X_R = concentration of biomass in return line from clarifier	[g VSS/m^3]
X_r = concentration of biomass in sludge drain	[g VSS/m^3]
X_e = concentration of biomass in effluent	[g VSS/m^3]

CHAPTER 3: METHODOLOGY / PROJECT WORK

3.0 Introduction

Phase 1:

There are two reactors which using aerobic treatment which are Reactor A and Reactor B. The Reactor A is used for short sludge age while the Reactor B use for long sludge age. For the first phase, the Safire's pharmaceutical wastewater will be treated using the aerobic treatment in the both reactors. The second phase will be measuring the result of the aerobic treatment through experiment. The concentration of ammonia and phosphorus will be measured through experiment.

Phase 2:

There are three reactors have been used for this project which divided into two parts, called as Train 1 and Train 2. For Train 1, two reactors are connected together for both anaerobic and aerobic treatment. For Train 2, there is only one reactor which use for just aerobic treatment. The influent of the pharmaceutical wastewater will flow to the Train 1 and Train 2 simultaneously. For Train 1, the wastewater will flow from the anaerobic reactor to aerobic reactor. The effluent will be taken at the aerobic reactor for the test. For Train 2, the wastewater will flow into the aerobic reactor and the effluent will be taken at the aerobic reactor. The flow rate of the influent is 5 mL per min.

3.1 Test procedure (aerobic treatment)

For this project, aerobic treatment was one of the solutions of the ammoniacal nitrogen (NH_3-N) and phosphorus treatment process for pharmaceutical waste. In this treatment, sludge from sewage treatment plant (STP) was used as the aerobic suspended growth. A variety of microorganisms were found in aerobic suspended growth used for removal of organic material. The bacteria in the sludge would digest the organic materials like (NH_3-

N) and PO_4. Therefore, the effluent of the treatment process would have less concentration of ammonia and phosphorus. For the aerobic treatment process, the influent of the treatment process was pharmaceutical waste. Then, the pharmaceutical waste flowed into the aeration tank. In the aeration tank, there would be the mixture of pharmaceutical waste and sludge. The mixture need to be aerated to ensure that the bacteria would growth and to prevent the bacteria die. The aerator was used to aerate the mixture. If the bacteria die, the treatment would fail because the bacteria were used to eat the organic materials. After the pharmaceutical waste flow to the aeration tank, it would flow to the clarifier. At the clarifier, the sludge was settled at the bottom of the clarifier. The pharmaceutical waste at the clarifier was already treated and the waste would flow to the effluent. Then, the sample of effluent could be taken for the ammonia and phosphorus test. The student needed to compare the concentration of ammonia and phosphorus between influent and effluent. The concentration of ammonia and phosphorus at the effluent should be less compare to influent. The mixture of the waste and sludge at the aeration tank also need to be tested to measure the content of the bacteria in the mixture.

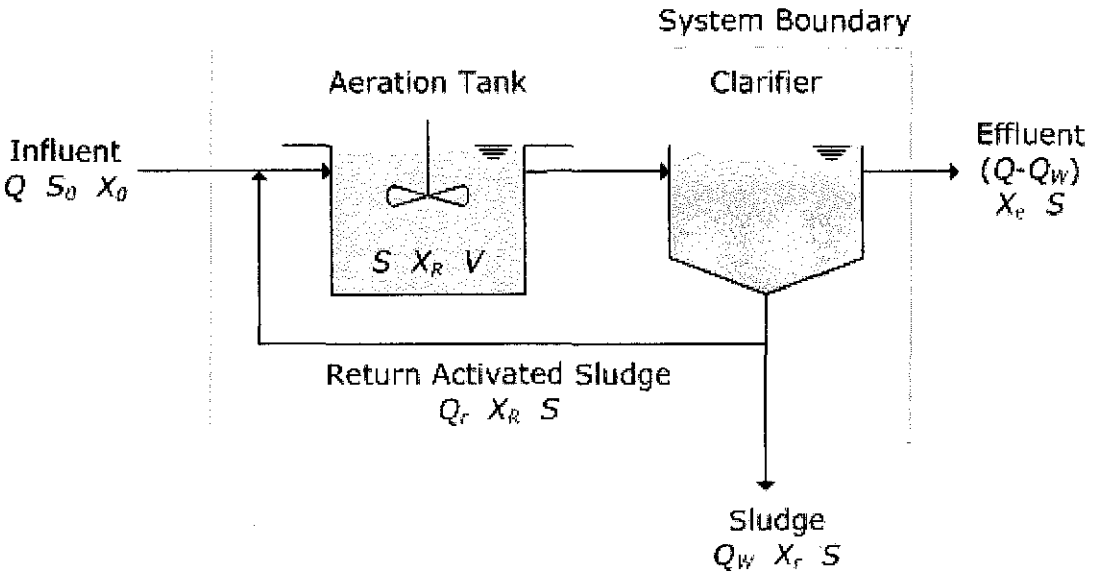


Figure 1: Activated-sludge process

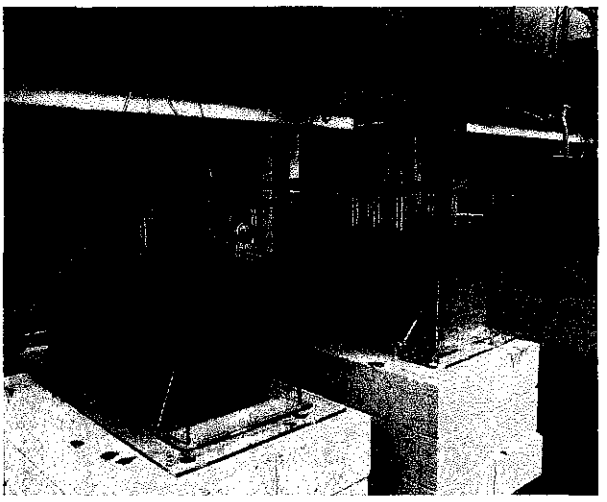


Figure 2: The reactors of the aerobic treatment process

3.1.1 Ammonia concentration experiment using Nessler Method

The method that had been used for the measurement of ammoniacal nitrogen (NH_3-N) is Nessler Method. The apparatus of the experiment are Nessler reagent, Mineral stabilizer, Polyvenyl chloride, DRB 2500, Distilled water, 50 ml beakers and 100 ml cylinders. The samples were prepared by taken from the influent and effluent tanks. Samples were diluted at the ratio of 1:10. After that, 3 drops of mineral stabilizer had been dropped into 25 ml of distilled water and 25ml of sample. Then, the mixture had been shaken. For the next step, 3 drops of polyvinyl chloride had been dropped into both 25 ml of distilled water and 25 ml sample. The mixture had been shaken. Then, 3 drops of Nessler reagent had been dropped into both 25 ml of distilled water and 25 ml sample. The mixture had been shaken. After that, 10 ml of both mixtures were put into the 10ml bottle. After 1 minute, the bottle with distilled water mixture had been put into the DRB 2500 device and the device had been read as 0.00 mg/L NH_3 -N. Then, the bottles with the sample mixture were put into the DRB 2500 device and the measurement had been read.

3.1.2 Phosphorus Analysis procedure

The apparatus of this experiment was DRB200, Tensette Pipet, Cylinders and distilled water while the chemical used are Total and Acid Hydrolyzable Test Vial, Potassium Persulfate Powder Pillow, Sodium Hydroxide Standard Solution, and Phosver 3 Powder Pillow. First, turn on the DRB 200 reactors. Preheat to 150 °C. Select the test. Use a Tensette Pipet to add 5.0 ml of sample to a Total and Acid Hydrolyzable Test Vial. Use a funnel to add the contents of one Potassium Persulafate Powder Pillow for Phosphone to the vial. Cap tightly and shake to dissolve. Insert the vial into the DRB 200. Close the protective cover. Press TIMER>OK. A 30 mm heating period will begin. When the timer expires, carefully remove the hot vial from the reactor. Insert it in a test tube rack and cool to room temperature. Wipe the outside of the vial with a damp cloth followed by a dry one. Use a Tensette Pipet to add 2 ml of 1.54 N Sodium Hydroxide Standard Solution to the vial. Insert the vial into the 16 mm cell holder. Press ZERO. The display will show 0.00 mg/L PO_4^{3-}. Use a funnel to add the content of one Phosver 3 Powder Pillow to the vial. Wipe the outside of the vial with a damp cloth followed by a dry one. Insert the vial into the 16 mm cell holder. Press READ. The display will show the measurement of phosphorus concentration in mg/L PO_4^{3-}.

3.2 Test procedure (anaerobic treatment)

Anaerobic wastewater treatment is the biological treatment of wastewater without the use of air or elemental oxygen. Many applications are directed towards the removal of organic pollution in wastewater, slurries and sludge. The organic pollutants are converted by anaerobic microorganisms to a gas containing methane and carbon dioxide, known as "biogas". For this project, the anaerobic is an effective solution for removal of chemical oxygen demand (COD) and total suspended solid (TSS) in pharmaceutical waste water. In this treatment, sludge from sewage treatment plant (STP) is used for the growth of anaerobic microorganisms. The sludge has been put into the anaerobic reactor for Train 1 until at the certain level of the reactor. The baffles had been put in the reactor to ensure that the detention time is longer. The sludge will not be aerated by the aerator. The bacteria in the sludge will digest the organic materials in the pharmaceutical wastewater.

3.3 Methodology of aerobic treatment for Phase 2

The aerobic treatment process for Phase 2 was similar with the Phase 1. In the aeration tank, the pharmaceutical waste and sludge had been mixed together. The bacteria in the sludge need oxygen to live and growth. Therefore, the mixture must be aerated to ensure that the bacteria will growth and to prevent the bacteria die. The aerators were used to aerate the mixture. The treatment would fail if the bacteria die, because the bacteria were used to digest the organic materials. The aeration process must continue about two weeks before started doing the experiment to ensure that the bacteria would acclimatize with the pharmaceutical wastewater. During two weeks time, the pharmaceutical wastewater must be flowing to the aeration tanks because the bacteria need nutrient to growth. The pharmaceutical wastewater was the nutrient for the bacteria growth. If, the pharmaceutical wastewater not be supply to the bacteria, the bacteria could die. After two weeks, the experiment had been conducted. The treatment process started when the influent which was pharmaceutical wastewater flowed into aerobic reactor. Then, the organic material would be digested by the bacteria at the aerobic reactor. The pharmaceutical wastewater would flow to the clarifier. At the clarifier, the sludge is

settled at the bottom of the clarifier. The pharmaceutical waste at the clarifier was already treated and the waste will flow to the effluent tanks. Then, the sample of effluents can be taken for the chemical oxygen demand (COD) and total suspended solid (TSS) test. The student needs to compare the concentration of chemical oxygen demand (COD) and total suspended solid (TSS) between influent and effluent to measure the removal efficiency. The concentration of chemical oxygen demand (COD) and total suspended solid (TSS) at the effluent should be less compare to influent. The mixture of the waste and sludge at the aeration tank also need to be tested to measure the content of the bacteria in the mixture.

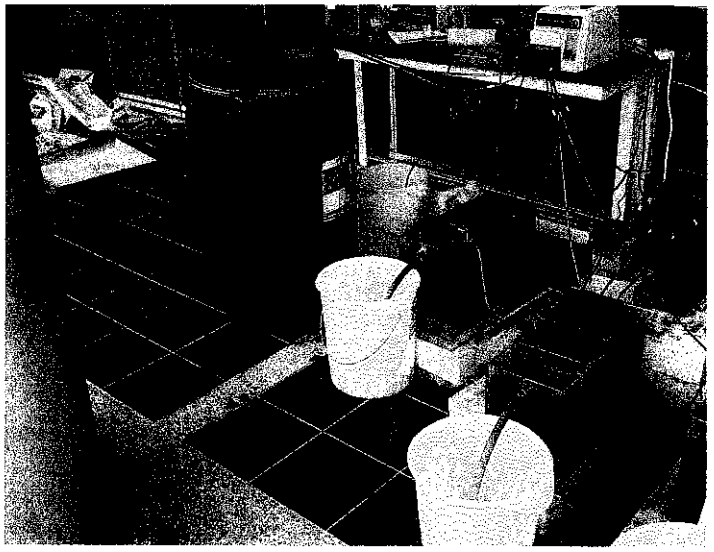


Figure 3: The reactors of the anaerobic-aerobic treatment process

3.4 Chemical Oxygen Demand (COD) procedure

2mL of water sample was dropped into a test tube containing Potassium Dichromate (K_2CrO_7) in sulfuric acid. The tube is shaken until heat is produced indicating an exothermic reaction. The thermo reactor is set at 150°C .The samples were placed in the reactor for 2 hours. The samples will then be tested for COD using spectrophotometer (HACH DR 2800).

3.5 Total Suspended Solids and Mix Liquor Suspended Solids Analysis

3.5.1 Preparation of Samples Procedure

Samples were taken from influent tank, effluent tank, anaerobic reactor and aerobic reactors using pipette and beakers. About 400 ml sample was taken from the influent which was pharmaceutical wastewater. For Train 1 samples, 400 ml sample was taken from anaerobic reactor to measure the concentration of COD and TSS. At the aerobic reactor, 400 ml sample was taken to measure the concentration of MLSS and MLVSS, settleability and sludge volume index (SVI). At the effluent tank, 400 ml sample was taken to measure concentration of COD and TSS of the effluent. For Train 2, 400 ml sample also was taken to measure the concentration of MLSS and MLVSS, settleability and sludge volume index (SVI).

3.5.2 Sample Analysis Procedure

For the filtration purposes, 21 filter papers and 21 aluminum foils had been prepared for TSS and MLSS experiment. For every sampling point, three reading must be taken to increase the efficiency of the experiment. After the filter papers and aluminum foils had been prepared, the foil for the sample at the aeration tanks had been weighed. For other aluminum foils, there would be no need to measure the weight of the foils. Then, for all sampling points the total weight of aluminum foils and filter papers had been measured. After that, place filtration apparatus with weighed filter in filter flask. Mix sample well and pour into a graduated cylinder to the selected volume. For each sampling points, the volume of each sample were 50 ml for influent, and both aeration tanks. The aeration tanks samples need to be dilute 1:50 to reduce the concentration of samples and to facilitate filtration process. For all effluents, the volumes of samples used for the experiment were 100 ml. After all samples had been prepared with right volume, suction to filter flask had been applied and the filters was rinsed with a small amount of distilled water. The selected volume had been poured into filtration apparatus. The sample was drawn through filter into filter flask. If sample filtrate is to be used for the total dissolved

solids test, the filter flask must be clean and free of any soluble residue. The graduated cylinder was rinsed into filtration apparatus with three successive 10 mL portions of distilled water, allowing complete drainage between each rinsing. The suction was continued for three minutes after filtration of final rinse was completed. The filter papers were dried in an oven at 103-105°C for at least 1 hour. After 1 hour, the filter papers in the aluminum foils must be leaved for cooling purpose. Then, the filter papers and aluminum foils had been reweighed. The increase in weight of the filter and solids compared to the filter alone represents the total suspended solids (TSS). Mix Liquor Suspended Solids (MLSS) in other hand is the volume of suspended solids in the mixed liquor of an aeration tank

3.5.3 Calculations

To determine the value of total suspended solids in mg/L, the following calculation should be used: Subtract the tare weight (the weight of the filter and support before sample is filtered) from the weight of the glass fiber filter, support and dried sample. The result is the weight of the dry solids in grams. Multiply the weight in grams by 1,000 mg/g to change to milligrams (mg). Divide by the sample size (in mL). Multiply the weight of the dry solids (in mg) by 1,000 mL/L to convert the sample size from mL to L.

3.6 Fixed and Volatile Solids Analysis Procedure

3.6.1 Description of test

Solids remaining after the analysis for total solids, total dissolved solids or total suspended solids are ignited at 550 +/-50°C to a constant weight. The results are called Total Volatile Solids (TVS), Dissolved Volatile Solids (DVS) and Total Volatile Suspended Solids (TVSS). The weight loss as a result of the ignition represents the volatile portion of the solids. The difference in weight of the ash and support vessel remaining after ignition compared to the empty vessel represents the fixed solids.

3.6.2 Equipment

The equipment for the fixed and volatile solids tests includes all of the apparatus and supplies necessary to perform total solids, total dissolved solids or total suspended solids tests with the following additional items. Muffle furnace, capable of operating at 550 +/- 50°C, Ceramic dishes for TSS, Furnace tongs and Insulated gloves. The apparatus of this experiment was DRB200, Tensette Pipet, Cylinders and distilled water while the chemical used are Total and Acid Hydrolyzable Test Vial, Potassium Persulfate Powder Pillow, Sodium Hydroxide Standard Solution, and Phosver 3 Powder Pillow. First, turn on the DRB 200 reactors. Preheat to 150 °C. Select the test. Use a Tensette Pipet to add 5.0 ml of sample to a Total and Acid Hydrolyzable Test Vial. Use a funnel to add the contents of one Potassium Persulafate Powder Pillow for Phosphone to the vial. Cap tightly and shake to dissolve. Insert the vial into the DRB 200. Close the protective cover. Press TIMER>OK. A 30 mm heating period will begin. When the timer expires, carefully remove the hot vial from the reactor. Insert it in a test tube rack and cool to room temperature. Wipe the outside of the vial with a damp cloth followed by a dry one. Use a Tensette Pipet to add 2 ml of 1.54 N Sodium Hydroxide Standard Solution to the vial. Insert the vial into the 16 mm cell holder. Press ZERO. The display will show 0.00 mg/L PO_4^{3-}. Use a funnel to add the content of one Phosver 3 Powder Pillow to the vial. Wipe the outside of the vial with a damp cloth followed by a dry one. Insert the vial into the 16 mm cell holder. Press READ. The display will show the measurement of phosphorus concentration in mg/L PO_4^{3-}.

CHAPTER 4: RESULT AND DISCUSSION

4.0 Introduction of Phase 1

Phase 1:

The purpose of the project for the first phase at Phase 1 was to investigate the removal efficiency of ammoniacal nitrogen (NH_3-N) and phosphorus (PO_4) from Safire's pharmaceutical wastewater using aerobic treatment. There were two reactors were used for the aerobic treatment which were reactor A and reactor B. Both reactors had the mixture of pharmaceutical wastewater and sludge and aerated by aerators. For the aerobic treatment the reactor A had used short sludge age while reactor B was used long sludge age. At short sludge age method at the reactor A, the sludge from the aeration tank had been washed out 1.5 Liter per day. For the reactor B, the sludge had been washed out 1.5 Liter every three days. The purpose of using the difference sludge age was to measure the removal efficiency of both methods for aerobic treatment.

4.1 Result of ammoniacal nitrogen (NH_3-N) concentration experiment

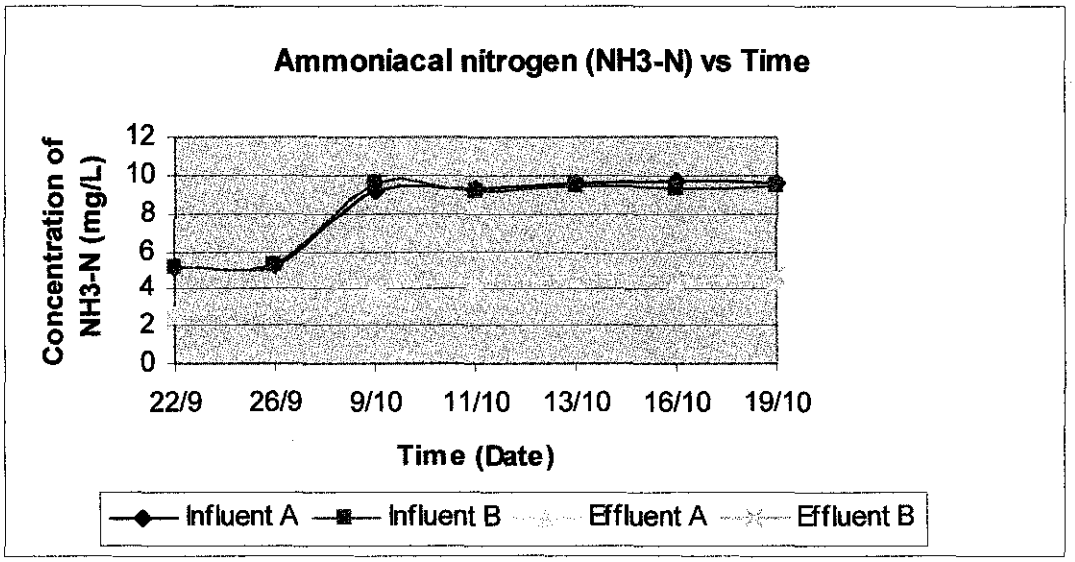


Figure 4: Graph of ammoniacal nitrogen (NH_3-N) versus Time

From the graph, it shows the decreasing of ammoniacal nitrogen (NH_3-N) concentration of pharmaceutical waste for the influent and effluent. The result of the experiment on 22nd September had been measured. The ammoniacal nitrogen (NH_3-N) concentration of the influent for the reactor A is 5.09 mg/L while for the reactor B is 5.15 mg/L. The result showed that there was only a small different of NH_3-N concentration between reactor A and B. For the effluent, the NH_3-N concentration of pharmaceutical wastewater for reactor A is 2.58 mg/L. For the reactor B, the NH_3-N concentration is 2.35 mg/L. The concentration difference between the influent and effluent for reactor A is 2.51 mg/L and for the reactor B is 2.80 mg/L. From calculation, the percentage decrease of the concentration between the influent and the effluent of NH_3-N for reactor A is 49.3% and for the reactor B is 54.3%. From the percentage result, it showed that treatment of both reactors was almost the same percentage. For 26th September result, the NH_3-N concentration of influent for the reactor A is 5.22 mg/L and for the reactor B is 5.31 mg/L. The NH_3-N concentration of effluent for the reactor A is 2.92 mg/L and for the reactor B is 2.64 mg/L. The concentration difference between the influent and effluent for reactor A is 2.30 mg/L and for the reactor B is 2.67 mg/L. The percentage decrease of the concentration between the influent and the effluent of NH_3-N for reactor A is 44.1% and for the reactor B is 50.3%. On 9th October 2006, a new influent had been taken from Safire Pharmaceuticals (M) Sdn. Bhd. Therefore, there was some difference of NH_3-N concentration between the previous influent and the new influent. The changes percentage of concentration between the new influent and effluent is about 44%. The change of the influent concentration was because of Safire Pharmaceuticals (M) Sdn. Bhd was not exactly did the same production everyday. They will produce different product everyday or every week depended on customers demand. Therefore, the changes of waste volume and concentration of the pharmaceutical wastewater could occur. For 9th October result, the NH_3-N concentration of influent for the reactor A is 9.21 mg/L and for the reactor B is 9.55 mg/L. The NH_3-N concentration of effluent for the reactor A is 3.99 mg/L and for the reactor B is 4.82 mg/L. The concentration difference between the influent and effluent for reactor A is 5.22 mg/L and for the reactor B is 4.73 mg/L. The percentage decrease of the concentration between the influent and the effluent of NH_3-N for reactor A is 44.1% and for the reactor B is 50.3%. Then, for 11th October result, the

NH_3-N concentration of influent for the reactor A is 9.32 mg/L and for the reactor B is 9.22 mg/L. The NH_3-N concentration of effluent for the reactor A is 4.43 mg/L and for the reactor B is 4.75 mg/L. The concentration difference between the influent and effluent for reactor A is 4.89 mg/L and for the reactor B is 4.47 mg/L. The percentage decrease of the concentration between the influent and the effluent of NH_3-N for reactor A is 52.4% and for the reactor B is 48.5%. For 13th October result, the NH_3-N concentration of influent for the reactor A is 9.59mg/L and for the reactor B is 9.41 mg/L. The NH_3-N concentration of effluent for the reactor A is 4.52 mg/L and for the reactor B is 4.68 mg/L. The concentration difference between the influent and effluent for reactor A is 5.07mg/L and for the reactor B is 4.73 mg/L. The percentage decrease of the concentration between the influent and the effluent of NH_3-N for reactor A is 52.8% and for the reactor B is 50.3%. For 16th October result, the NH_3-N concentration of influent for the reactor A is 9.69 mg/L and for the reactor B is 9.27 mg/L. The NH_3-N concentration of effluent for the reactor A is 4.49 mg/L and for the reactor B is 4.75 mg/L. The concentration difference between the influent and effluent for reactor A is 5.20 mg/L and for the reactor B is 4.52 mg/L. The percentage decrease of the concentration between the influent and the effluent of NH_3-N for reactor A is 53.7% and for the reactor B is 48.8%. For the 19th October result, the NH_3-N concentration of influent for the reactor A is 9.58mg/L and for the reactor B is 9.41 mg/L. The NH_3-N concentration of effluent for the reactor A is 4.55 mg/L and for the reactor B is 4.84 mg/L. The concentration difference between the influent and effluent for reactor A is 5.03 mg/L and for the reactor B is 4.57 mg/L. The percentage decrease of the concentration between the influent and the effluent of NH_3-N for reactor A is 52.5% and for the reactor B is 48.6%. The short sludge had been used for reactor A to treat the pharmaceutical waste while long sludge age for the reactor B. The decreasing of the ammoniacal nitrogen (NH_3-N) concentration proves the successful of the aerobic treatment. From the result, it showed that there are not much different of the treatment between short and long sludge age reactors. The ammoniacal nitrogen NH_3-N could be treated because there are bacteria exist in the sludge. The bacteria growth in the reactor had digested the ammoniacal nitrogen (NH_3-N) in both reactors. Therefore, the concentration of the ammoniacal nitrogen (NH_3-N) in the pharmaceutical was decrease and had been measured from conducting experiment. There

are two area of the graph those showed constants which were between 22nd September and 26th September and between 9th October and 19th October. The ammoniacal nitrogen (NH_3-N) concentration the pharmaceutical wastewater in the influent for both reactors changed starting 9th October because the student put the new influent at both reactors. It was observed that there was a difference in the ammoniacal nitrogen (NH_3-N) concentration between the previous influent and the new influent. Therefore, the effluent result of both reactors also become different and higher compare to the previous effluent.

4.2 Result of phosphorus (PO_4) concentration experiment

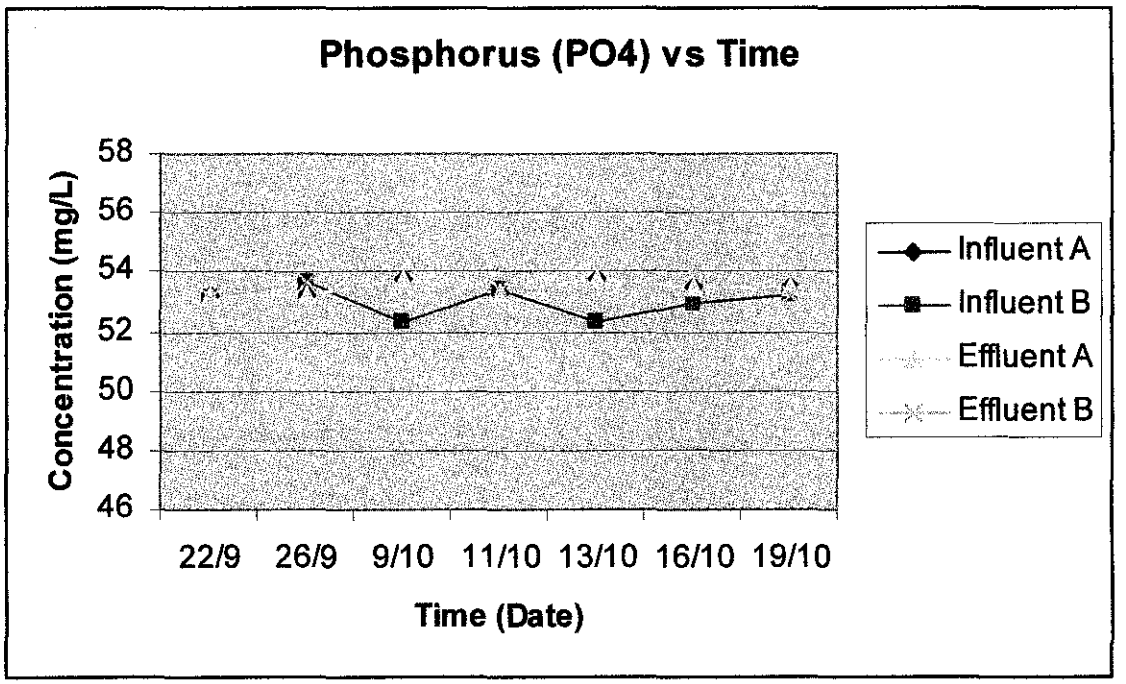


Figure 5: Graph of phosphorus (PO_4) versus Time

From the graph, it showed that there was no change of phosphorus (PO_4) concentration in the pharmaceutical waste between influent and effluent. But there was a little difference between the influent and effluent. The small difference of the result may be cause by error in the measurement. From the result, it was concluded that the aerobic treatment could not treat the phosphorus because there was no change of phosphorus (PO_4)

concentration when comparing the influent and effluent result. As a conclusion, the aerobic degradation treatment could not treat the phosphorus (PO_4).

4.3 Problem faced

4.3.1 High volume of sludge

The aerator cannot afford to well mix the pharmaceutical waste and sludge together if the volume of sludge is too high. Therefore, the aerobic treatment will not function properly. As a result, the settlement will occur at the bottom of the reactors. This settlement of sludge at the bottom of the reactors has disturbed the movement of the treatment and caused the overflow around the reactors. By doing the settlebility test, a 1000ml of mixing of wastewater and sludge had been taken and the sample should be observed for 30minutes to see the settlement. If the settlement is around 200ml therefore the volume of sludge added is good but for our project we had got 400ml of settlement. This shows that we have double the volume of sludge. To overcome this problem, both reactors have been mix together and 20 liters of the mixing has been thrown out. After that, 20 liters of pharmaceutical wastewater was added and this has stabilized the presence of the sludge. This has been proved by the result of MLSS (Mix Liquor Suspended Solid) from one of the group members.

4.3.2 Slow aeration process

Slow aeration process can affect the mixing process and the supplement of oxygen to the bacteria. If the process to aerate the mixing fails the whole process of aerobic treatment will be failed. Furthermore, insufficient oxygen will slow the process of the bacteria to break down and digest the organic matters. Therefore, the replacements of the aerators have been taken by choosing more powerful aerators. In addition, the long bar aerators was needed instead of the short bar aerators in order to make sure the mixing process was covered entire the reactor.

4.3.3 Bubbles produced by the aeration of pharmaceutical wastewater

A large volume of bubbles produced when the mixture of sludge and pharmaceutical waste were aerated. Accordingly to Safire Pharmaceuticals Executive Quality Control, Mr. Ali Hanafiah, the pharmaceutical waste could also mix with the detergents that they have used at the Safire Pharmaceuticals (M) Sdn. Bhd.. Therefore, the bubbles maybe caused by the presence of the detergent in pharmaceutical wastewater. After discussion between the group members, a decision to moderate the aeration had been agreed and it successfully has reduced the probability of pharmaceutical wastewater to create more bubbles. By the way, the moderation of aerators is still can afford to mix up the sludge and pharmaceutical waste together in the reactors.

4.4 Introduction of Phase 2

Phase 2:

For the second phase, the project was executed to investigate the removal efficiency of total suspended solid (TSS) and chemical oxygen demand (COD) using anaerobic-aerobic treatment. There are three reactors have been used for this project which divided into two parts, called as Train 1 and Train 2. For Train 1, two reactors are connected together for both anaerobic and aerobic treatment. For Train 2, there is only one reactor which use for just aerobic treatment. The influent of the pharmaceutical wastewater will flow to the Train 1 and Train 2 simultaneously. For Train 1, the wastewater will flow from the anaerobic reactor to aerobic reactor. The effluent will be taken at the aerobic reactor for the test. For Train 2, the wastewater will flow into the aerobic reactor and the effluent will be taken at the aerobic reactor.

4.5 Result of COD experiment for Aerobic Treatment at Train 1 (T2) and Train 2 (T2)

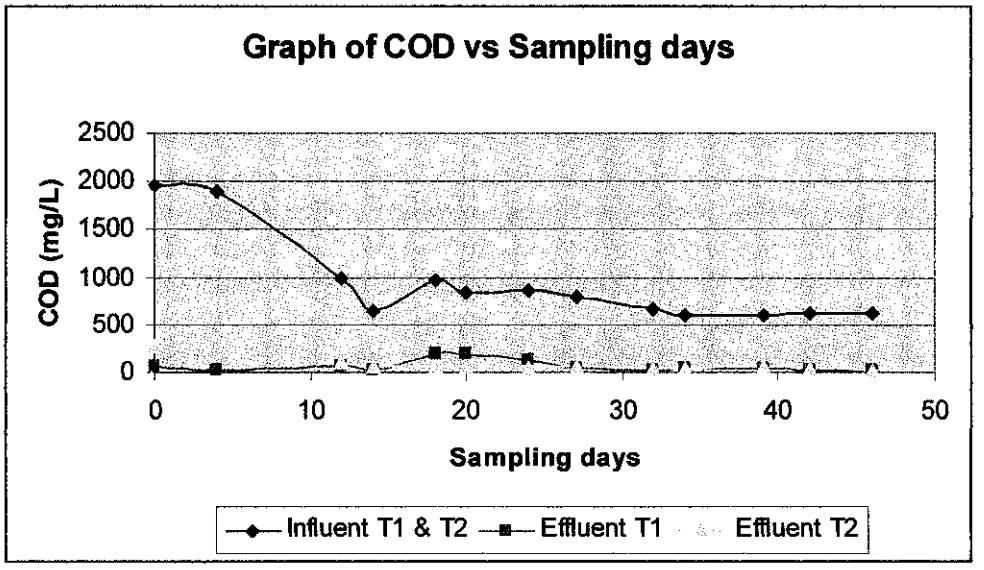


Figure 6: Graph of COD versus Sampling days

From the result, it shows that the comparison of concentration between the influent and effluent of pharmaceutical wastewater after treating using aerobic treatment at Train 1. The concentration of chemical oxygen demand (COD) on the 1st day was 1953 mg/L for

the influent and 61 mg/L for the effluent. The percentage of the COD that had been removed is 96.9% which was very high. For the result on the 4th days, the COD concentration for the influent was 1893 mg/L while for the effluent was 28.67 mg/L. The percentage of the COD that had been removed was very high which 98.4%. For Train 2, the COD of the effluent was 191 mg/L. So, the percentage removal of COD for Train 2 was 90%. The result on 12th days shows that the COD concentration of the influent was low compare to before which is 986.67 mg/L. This was because a new influent had been put on 17th February which was on 8th days for the experiment. The concentration of new pharmaceutical wastewater was lower compare to the previous pharmaceutical wastewater. However, the COD still can be removed from the experiment. The COD concentration for the effluent Train 1 on 12th days is 65 mg/L. The percentage of COD removal for Train 1 was 93.8%. Meanwhile, the COD concentration for the effluent Train 2 on 12th days is 99.67 mg/L. The percentage of COD removal for Train 2 was 89.9%. For the result on the 14th days, the COD concentration for the influent was 643 mg/L while for the effluent Train 1 is 24.67 mg/L. The percentage of the COD that had been removed was quite high which 96.1%. The COD concentration for the effluent Train 2 on 14th days was 69.33 mg/L. The percentage of COD removal for Train 2 was 89.2%. On the 18th days, the COD concentration for the influent is 978.33 mg/L while for the effluent is 190.67 mg/L. The percentage of the COD that had been removed for Train 1 was high which 80.5%. The COD concentration for the effluent Train 2 on 18th days was 70 mg/L. The percentage of the COD that had been removed for Train 2 was quite high which 92.8%. For the result on the 20th days, the COD concentration for the influent is 846.67 mg/L while for the effluent is 184.33 mg/L. The percentage of the COD that had been removed is high which 78.2%. Meanwhile, the COD concentration for the effluent Train 2 on 20th days is 58.33 mg/L. The percentage of COD removal for Train 2 was 93.1%. On the 24th days, the COD concentration for the influent is 865 mg/L while for the effluent was 126 mg/L. The percentage of the COD that had been removed very high which was 85.4%. The COD concentration for the effluent Train 2 on 24th days is 49 mg/L. The percentage of COD removal for Train 2 was 94.3%. For the result on the 27th days, the COD concentration for the influent is 790.50 mg/L while for the effluent is 40 mg/L. The percentage of the COD that had been removed is high which 94.9%. The

COD concentration for the effluent Train 2 on 27th days is 61.5 mg/L. The percentage of COD removal for Train 2 was 92.2%. On the 32nd days, the COD concentration for the influent is 670 mg/L while for the effluent is 31.67 mg/L. The percentage of the COD that had been removed very high which is 95.3%. The COD concentration for the effluent Train 2 on 32nd days is 52 mg/L. The percentage of COD removal for Train 2 was 92.2%. For the result on the 34th days, the COD concentration for the influent is 612.67 mg/L while for the effluent is 32.67 mg/L. The percentage of the COD that had been removed is high which 94.7%. The COD concentration for the effluent Train 2 on 34th days is 51.67 mg/L. The percentage of COD removal for Train 2 was 91.6%. From the result, it showed that the COD concentration of the influent decreasing. This thing might cause by chemical reaction of the influent because after 1 month the colour of the influent changes. On 39th days, the COD result for influent is maintained at 610mg/L while for the effluent Train 1 was 35 mg/L. The percentage of the COD that had been removed very high which is 94.3%. The COD concentration for the effluent Train 2 on 39th days is 55 mg/L. The percentage of COD removal for Train 2 was 91%. On 42nd days, the COD result for influent is maintained at 615 mg/L while for the effluent is 32 mg/L. The percentage of the COD that had been removed very high which is 94.8%. The COD concentration for the effluent Train 2 on 42nd days is 52 mg/L. The percentage of COD removal for Train 2 was 93.2%. Then, on 46th days, the COD result for influent is maintained at 620 mg/L while for the effluent for Train 1 was 31 mg/L. The percentage of the COD that had been removed very high which is 95%. The COD concentration for the effluent Train 2 on 46th days is 31 mg/L. The percentage of COD removal for Train 2 was 95%. The lowest COD for the influent is on the 39th days. From the experiment, we can conclude that the removal efficiency of aerobic treatment at Train 1 is high because the percentage of COD remove is high.

4.6 Total Suspended Solid (TSS) for Aerobic Treatment at Train 1 (T1) and Train 2(T2)

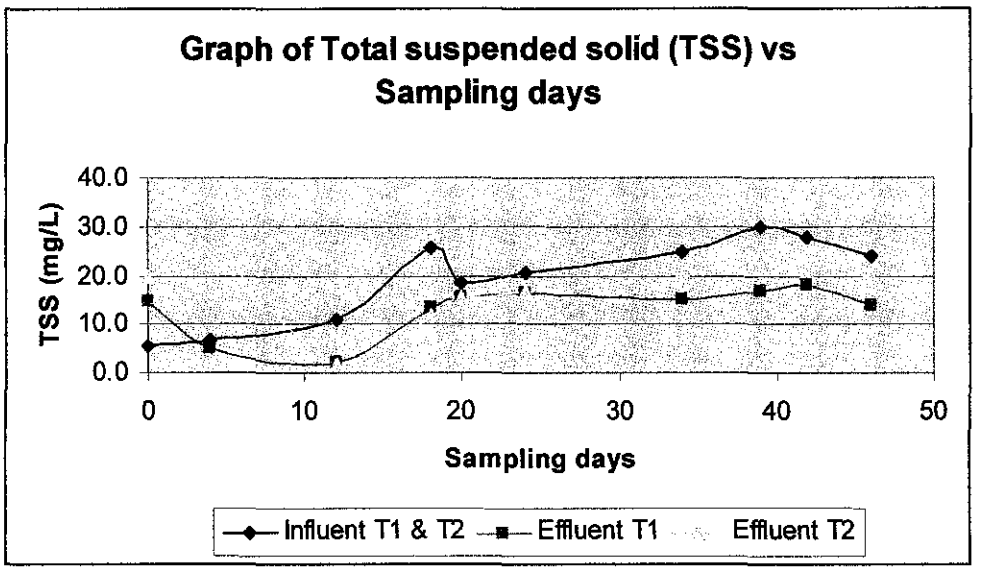


Figure 7: Graph of TSS versus Sampling days

The result shows comparison between the influent and effluent of total suspended solid (TSS) of pharmaceutical wastewater after treating using aerobic treatment at Train 1. On the 1st days, the TSS effluent Train 1 concentration is 14.7 mg/L while TSS influent concentration is 5.7 mg/L. The TSS effluent of Train 2 was quite high which was 19.7 mg/L. The TSS effluent concentration is quite high might be because the sludge that had been washed out to the clarifier and had affected the result. On the 4th days, the result becomes better. The TSS influent is 6.7 mg/L while TSS effluent is 5.0 mg/L. The percentage of TSS removed is 25.4 %. But, the TSS result for train 2 still high which was 25.3 mg/L. The result of the experiment on 12th days becomes even better. The TSS influent concentration was 11.0 mg/L while the TSS effluent concentration for Train 1 was 2.0 mg/L. For Train 2 effluent, the TSS concentration was 1.7 mg/L. The percentage of TSS removed for Train 1 was 81.8 % while for Train 2 was 84.5%. On the 18th days, the result of TSS for influent was 25.7 mg/L while TSS effluent of Train 1 was 13.67 mg/L. The percentage of TSS removed for Train 1 was 46.8 %. For Train 2 effluent, the TSS concentration was 11.7 mg/L. The percentage of TSS removed for Train 2 was 54.5%. From the result, it showed that the TSS removal percentage had been improved.

On the 20th days, the result of TSS for influent is 18.3 mg/L while TSS effluent for Train 1 was 15.67 mg/L. For Train 2 effluent, the TSS concentration was 15.7 mg/L. The percentage of TSS removed for Train 1 was 14.4 % while for Train 2 was 14.2%. The decrease of percentage removal might be cause by the washed out of sludge to the effluent. For the result on the 24th days, the TSS for influent is 20.7 mg/L while TSS effluent is 16.33 mg/L. The percentage of TSS for Train 2 removed was 21.11 %. The TSS effluent of Train 2 was 17 mg/L. The percentage of TSS for Train 2 removed was 17.9 %. On the 34th days, the result of TSS for influent is 25 mg/L while TSS effluent for Train 1 was 15 mg/L. For Train 2 effluent, the TSS concentration was 15.7 mg/L. The percentage of TSS removed for Train 1 was 40 % while for Train 2 was 37.2%. On the 39th days, the result of TSS for influent is 30 mg/L while TSS effluent is 17 mg/L. The percentage of TSS removed very high which is 43 %. The TSS effluent of Train 2 was 22 mg/L. The percentage of TSS for Train 2 removed was 26.7 %. On the 42nd days, the result of TSS for influent is 28 mg/L while TSS effluent is 18 mg/L. The percentage of TSS removed very high which is 35.7 %. On the 46th days, the result of TSS for influent is 24 mg/L while TSS effluent of Train 1 is 14 mg/L. The percentage of TSS effluent for train 1 removed very high which is 41.7 %. The TSS effluent of Train 2 was 20 mg/L. The percentage of TSS for Train 2 removed was 16.7 %. From the result, it shows that the TSS for the influent on 32nd days is quite high. This could cause by the red suspended solid produce in the influent after 1 month. The suspended solid might cause by the chemical reaction. As a conclusion, the aerobic treatment can remove TSS of the pharmaceutical wastewater.

4.7 Mixed Liquor Suspended Solid (MLSS) for Train 1 (T1) and Train 2 (T2)

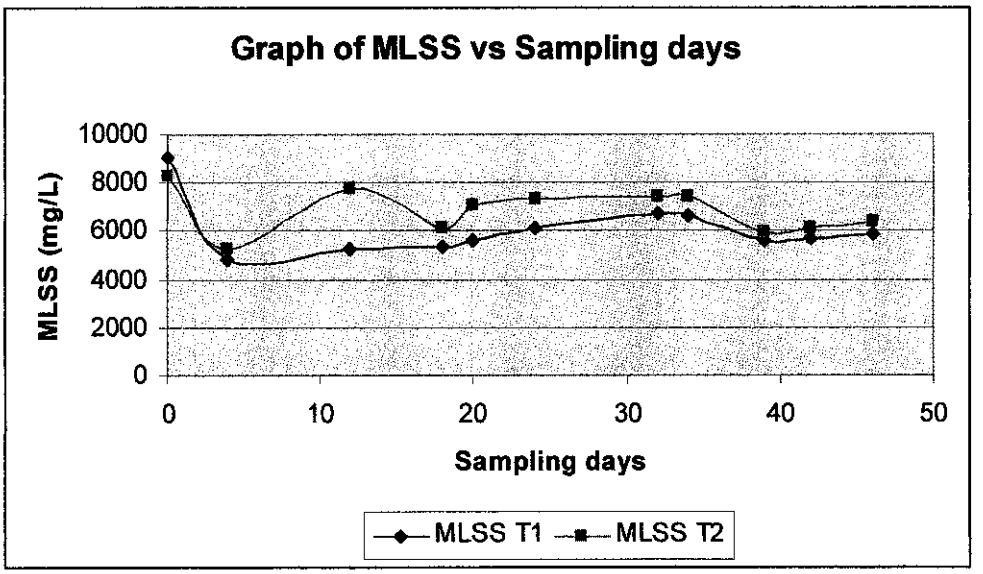


Figure 8: Graph of MLSS versus Sampling days

The result shows the comparison of Mix Liquor Suspended Solid (MLSS) between Train 1 and Train 2. From the result, we can conclude that the MLSS for both Trains are not consistent. The MLSS for both Trains must be maintaining between the ranges of 4000 to 5000 mg/L. From the graph, it shows that only MLSS for Train 1 maintained between the ranges of 4000 to 5000 mg/L which is from 4^{th} days until 18^{th} days. But, for other days, the MLSS become quite high might be cause by the growth of bacteria. To ensure that the MLSS could be maintained for both reactors, the monitoring of the reactors must be done every day to ensure that there would be no or little sludge wash out from the reactors. If the MLSS is higher than the range, the concentration of the sludge in the reactor must been reduced. The sludge must be thrown out from the reactor at some calculated volume to ensure that the MLSS maintained the ranges of 4000 to 5000 mg/L.

4.8 Mixed Liquor Volatile Suspended Solid (MLVSS) for Train 1(T1) and Train 2 (T2)

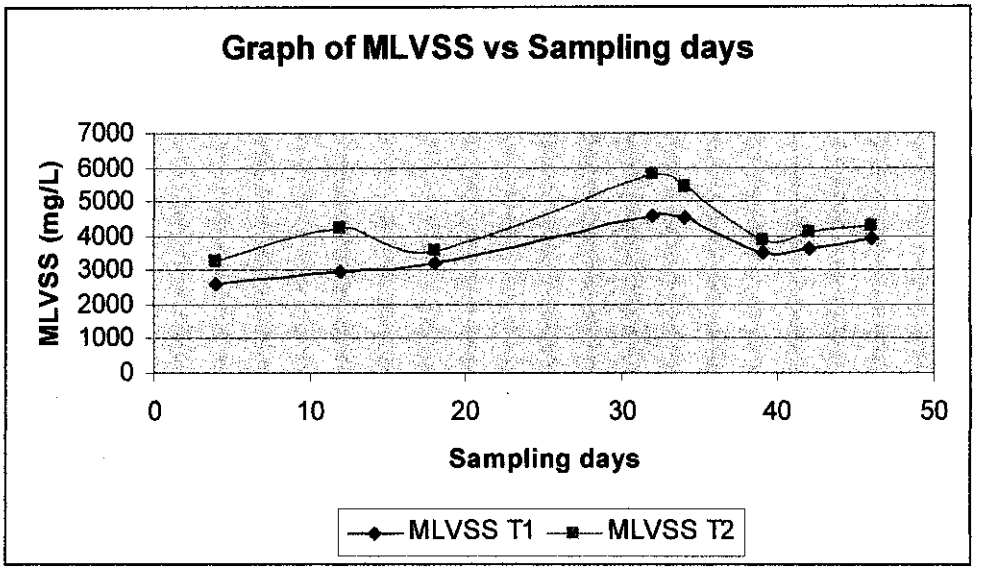


Figure 9: Graph of MLVSS versus Sampling days

The result shows the comparison of Mixed Liquor Volatile Suspended Solid (MLVSS) between Train 1 and Train 2. From the result, we can conclude that the MLVSS for both Trains are slightly consistent. At the beginning of the project, the MLVSS for both Train 1 and Train 2 quite low which were 2500 mg/L and 3100 mg/L. These were the lowest MLVSS for the project. Suddenly, between 32nd and 34th days, the MLVSS became higher which both concentration for Train 1 were 4600 mg/L and 4533 mg/L. While for Train 2, the MLVSS values were 5800 mg/L and 5422 mg/L. The MLVSS for Train 2 is higher compare to Train 1. When comparing the result of MLVSS and MLSS, it shows that both of them are almost the same. So, the value of MLSS must be maintained through out the whole project in order to obtain good results for both MLSS and MLVSS.

4.9 Graph comparison between Mix Liquor Suspended Solid (MLSS) and Mix Liquor Volatile Suspended Solid (MLVSS) for Train 1 (T1) and Train 2 (T2)

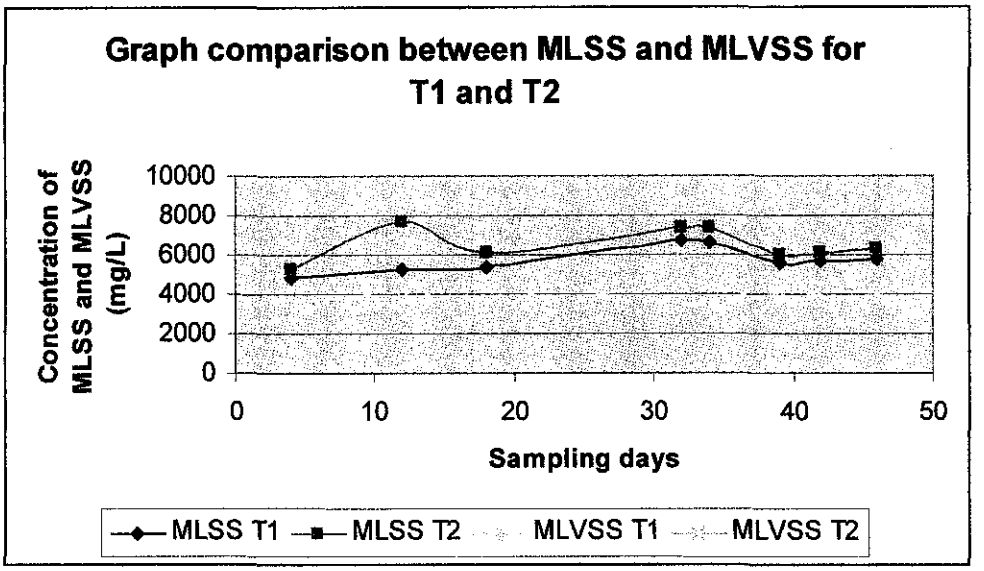


Figure 10: Graph comparison MLSS and MLVSS for Train 1 (T1) and Train 2 (T2)

From the graph, it shows that the comparison between MLSS and MLVSS for both Train 1 and Train 2. From the graph, at the lowest concentration of MLVSS and MLSS for Train 1 both were 2600 mg/L and 4867 mg/L. So, the ratio of MLVSS to MLSS for Train 1 on the 4^{th} days was 0.53 which mean 1:2. For Train 2, concentration of MLVSS and MLSS both were 3250 mg/L and 5300 mg/L. So, the ratio of MLVSS to MLSS for Train 1 on the 4^{th} days was 0.61 which mean almost 1:2. So, from the result we can conclude that the concentration of MLSS was about two times higher comparing to MLVSS. So, during the project, monitoring must be done to ensure that the concentration of MLSS and MLVSS maintain at certain value to ensure that the project would be successful.

4.10 Settleability Test for Train 1 and Train 2

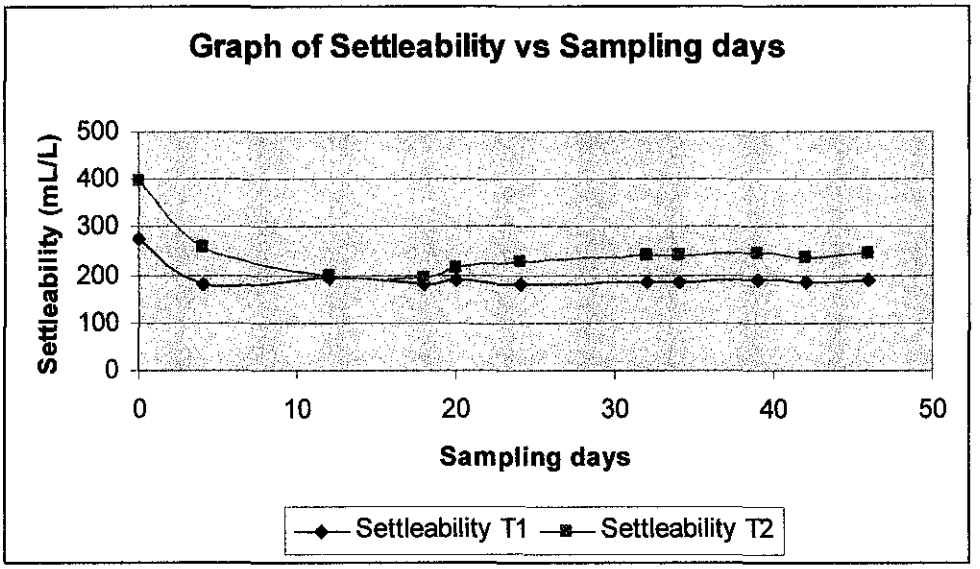


Figure 11: Graph of Settleability versus Sampling days

From the result, it shows the settleability of the mixture of sludge and pharmaceutical wastewater in the aeration tank. On 1st day, the settleability of Train 1 is 278 mL/L while for the Train 2 is 397 mL/L. On 4th February, the settleability of Train 1 is decrease to 180 mL/L. This thing might happen because the sludge and bacteria bacteria had been wash out through out the experiment. The settleability of Train 2 is also decrease to 260 mL/L which might also cause by the wash out of the sludge and bacteria. On 12th days, the settleability of Train 1 and Train 2 had been maintain and almost the same. The settleability of the sludge for Train 1 is 195 mL/L while for the Train 2 is 200 mL/L. From the result, we can conclude that the settleability for both Trains had been maintained on 12th day. The settleability of the sludge should be around 200 mL/L. So, in order to get the good result for the treatment process, the settleability must be maintain around that level and must be monitor always.

4.10 Sludge Volume Index (SVI) for Train 1(T1) and Train 2(T2)

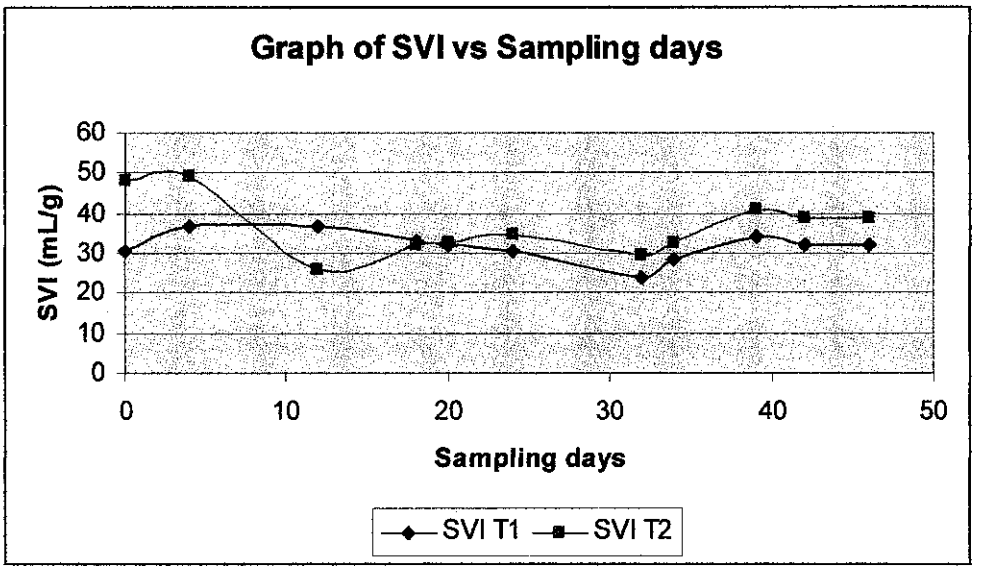


Figure 12: Graph of SVI versus Sampling days

From the graph, it shows the comparison of the sludge volume index (SVI) between Train 1 and Train 2. The SVI value on 1st day for Train 1 is 30.66 mL/g which is lower compare to Train 2 at the value of 48.12 mL/g. On 4th days, the results of SVI still maintain which are 36.99 mL/g for Train 1 and 49.06 mL/g for Train 2. However, on 12th days, the result had been changed which SVI for Train 1 become higher compared to Train 2. SVI for Train 1 is 36.79 mL/g while for Train 2 is 25.86 mL/g. On 18th days, the SVI result for Train 1 and Train 2 is almost the same which are 33.33 mL/g and 32.23 mL/g. On 20th days, the SVI result for Train 1 and Train 2 is still maintained which are 32.20 mL/g and 32.58 mL/g. The SVI for both Trains must be monitor and try to be maintained at the value that almost the same for both Trains. The purpose of this experiment was to measure the volume of sludge in the mixture of pharmaceutical wastewater and sludge. The volume of sludge in the aeration tanks must be maintained to ensure that the treatment system could treat the pharmaceutical wastewater effectively.

CHAPTER 5: CONCLUSION

The project was conducted in two phases to measure the ability of treatment system which were aerobic treatment and anaerobic-aerobic treatment system in order to treat all parameters which were ammoniacal nitrogen (NH_3-N), phosphorus (PO_4), chemical oxygen demand (COD) and total suspended solid (TSS). The bacteria growth needs to be maintained to ensure that they can digest the ammonia and phosphorus to treat the organic material in the pharmaceutical waste. Aerobic treatment is proven effective for the ammonia treatment from the result of the experiment. But, the treatment can not treat phosphorus well. From the experiment of the first phase of the project, it showed that the effluent concentration of ammoniacal nitrogen (NH_3-N) in pharmaceutical wastewater reduced when compared it to the influent. The maximum percentage removal of the ammoniacal nitrogen (NH_3-N) quite high which was 54.3%. But, there was no change between the influent and effluent of phosphorus (PO_4) which means no removal of phosphorus using aerobic treatment. For the second phase of the project, it showed that the effluent concentration of chemical oxygen demand (COD) and total suspended solid (TSS) in pharmaceutical wastewater were reduced when compared them to the influent. The maximum percentage removal of COD for pharmaceutical wastewater was 98.1% which quite high. Meanwhile, the maximum percentage removal of TSS for pharmaceutical wastewater was 46.8%. So, it can be concluded that the aerobic treatment could treat ammoniacal nitrogen (NH_3-N) but could not treat phosphorus (PO_4). However, the anaerobic-aerobic treatment could successfully treat both the chemical oxygen demand (COD) and total suspended solid (TSS). From the results of the project, the anaerobic-aerobic treatment was the better treatment system compare to aerobic treatment because the treatment system can treat more parameters compare to aerobic treatment system. The anaerobic-aerobic treatment system was more effective in treatment and also cost effective which was perfect treatment system to be purpose to a wastewater company. As a recommendation, the changes of the treatment system must be done for anaerobic to increase the efficiency of anaerobic-aerobic treatment. The reactor for anaerobic treatment must be fully close not partially close like this project to ensure that the treatment was fully anaerobic and not partially anaerobic.

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APPENDIX

APPENDIX 1

List of expected chemical in pharmaceutical waste water:

1. Methanol
2. Ethanol
3. Sodium Chloride
4. Cleaning Agent (Decon 90)
5. Sanitization Agent (Sodium Hypochloride)
6. Sugar
7. Colorization Agent
8. Chloride Salt
9. Chlorine

APPENDIX 2

RESULT OF AMMONIACAL NITROGEN (mg/L)

22nd September 2006

Sample	1	2	3	Average
Influent A	5.15	5.11	5.01	5.09
Influent B	5.21	5.08	5.16	5.15
Effluent A	2.45	2.61	2.68	2.58
Effluent B	2.41	2.22	2.42	2.35

26th September 2006

Sample	1	2	3	Average
Influent A	5.31	5.15	5.2	5.22
Influent B	5.05	5.39	5.49	5.31
Effluent A	3.08	2.87	2.81	2.92
Effluent B	2.51	2.59	2.82	2.64

9th October 2006

Sample	1	2	3	Average
Influent A	9.31	9.15	9.17	9.21
Influent B	9.45	9.62	9.58	9.55
Effluent A	3.88	4.11	3.98	3.99
Effluent B	4.91	4.77	4.78	4.82

11th October 2006

Sample	1	2	3	Average
Influent A	9.22	9.15	9.59	9.32
Influent B	9.35	9.12	9.19	9.22
Effluent A	4.55	4.39	4.35	4.43
Effluent B	4.63	4.71	4.91	4.75

13th October 2006

Sample	1	2	3	Average
Influent A	9.22	9.15	9.59	9.32
Influent B	9.35	9.12	9.19	9.22
Effluent A	4.55	4.39	4.35	4.43
Effluent B	4.63	4.71	4.91	4.75

16th October 2006

Sample	1	2	3	Average
Influent A	9.59	9.74	9.74	9.69
Influent B	9.58	9.51	8.72	9.27
Effluent A	4.29	4.62	4.56	4.49
Effluent B	4.55	4.71	4.99	4.75

19th October 2006

Sample	1	2	3	Average
Influent A	9.39	9.83	9.52	9.58
Influent B	9.61	9.28	9.34	9.41
Effluent A	4.29	4.62	4.56	4.49
Effluent B	4.71	4.82	4.84	4.75

APPENDIX 3

RESULT OF PHOSPHORUS CONCENTRATION (mg/L)

22nd September 2006

Sample	1	2	3	Average
Influent A	53.67	53.15	52.87	53.23
Influent B	51.88	53.78	53.67	53.11
Effluent A	53.67	52.15	53.87	53.23
Effluent B	51.88	53.78	53.67	53.11

26th September 2006

Sample	1	2	3	Average
Influent A	52.17	53.41	54.11	53.23
Influent B	54.21	53.66	53.05	53.64
Effluent A	52.17	53.41	54.11	53.23
Effluent B	54.21	53.66	53.05	53.64

9th October 2006

Sample	1	2	3	Average
Influent A	53.51	54.2	53.45	53.72
Influent B	53.21	51.56	52.19	52.32
Effluent A	53.51	54.2	53.45	53.72
Effluent B	53.21	51.56	52.19	52.32

11th October 2006

Sample	1	2	3	Average
Influent A	53.21	53.63	53.15	53.33
Influent B	53.72	53.26	53.31	53.43
Effluent A	53.21	53.63	53.15	53.33
Effluent B	53.72	53.26	53.31	53.43

13th October 2006

Sample	1	2	3	Average
Influent A	54.56	53.11	53.49	53.72
Influent B	50.88	51.97	54.11	52.32
Effluent A	54.56	53.11	53.49	53.72
Effluent B	50.88	51.97	54.11	52.32

16th October 2006

Sample	1	2	3	Average
Influent A	55.08	53.22	52.14	53.48
Influent B	52.67	52.73	53.33	52.91
Effluent A	55.08	53.22	52.14	53.48
Effluent B	52.67	52.73	53.33	52.91

19th October 2006

Sample	1	2	3	Average
Influent A	54.21	53.66	52.66	53.51
Influent B	52.17	53.65	53.84	53.22
Effluent A	54.21	53.66	52.66	53.51
Effluent B	52.17	53.65	53.84	53.22

APPENDIX 4

Calculation of Chemical Oxygen Demand (COD), Nitrogen (N) and Phosphorus (P) ratio:

The influent concentration of the parameters that were measured:

(i) Ammoniacal nitrogen (NH_4N) = 9 mg/L

From the calculation, Nitrogen = 1.75 mg/L

(ii) Phosphorus = 50 mg/L

(iii) COD = 2100 mg/L

Therefore;

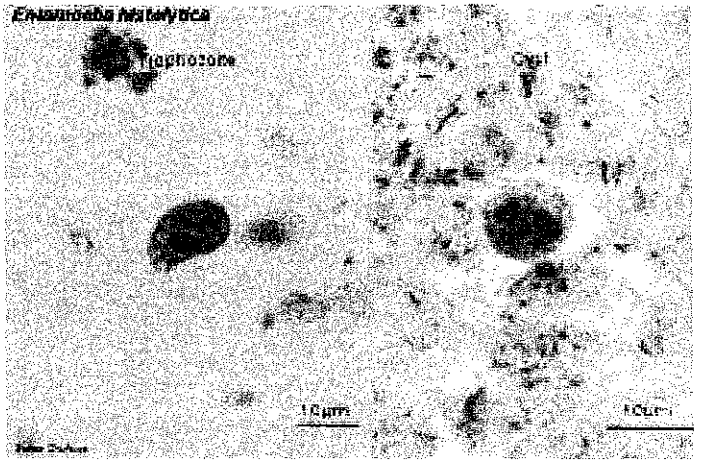
COD : Nitrogen : Phosphorus

2100 : 1.75 : 50

1200 : 1 : 29

APPENDIX 5

- Bacteria pictures that had been found in the sludge using microscope.



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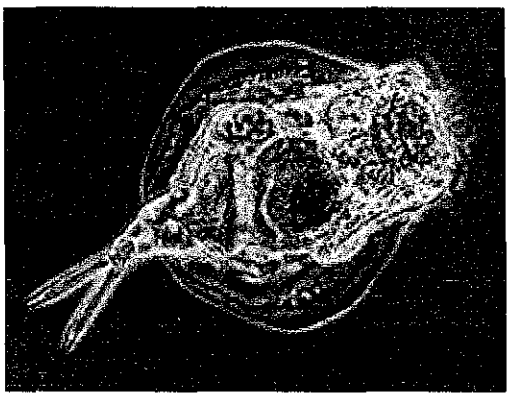

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APPENDIX 6

1. Chemical Oxygen Demand (COD) datasheet

Dates	Sampling Days	Flow Rate		Train 1		Train 2
		Q	Influent COD	Effluent COD		
		(L/day)		Anaerobic	Aerobic	Aerobic
2/9/2007	0	7.2	1953.00	106.67	60.67	273.67
2/13/2007	4	7.2	1893.33	52.67	28.67	191.00
2/21/2007	12	7.2	986.67	104.00	65.00	99.67
2/23/2007	14	7.2	643.00	49.33	24.67	69.33
2/27/2007	18	7.2	978.33	190.67	90.67	70.00
3/1/2007	20	7.2	846.67	184.33	84.33	58.33
3/5/2007	24	7.2	865.00	126.00	26.00	49.00
3/8/2007	27	7.2	790.50	74.5	40	61.5
3/13/2007	32	7.2	670.00	81	31.67	52
3/15/2007	34	7.2	612.67	65	32.67	51.67

2. Total Suspended Solid (TSS) datasheet

Dates	Sampling Days	Flow Rate		Train 1		Train 2
		Q	Influent TSS	Effluent TSS		
		(L/day)		Anaerobic	Aerobic	Aerobic
2/9/2007	0	7.2	5.7	18.0	14.7	19.7
2/13/2007	4	7.2	6.7	27.0	5.0	25.3
2/21/2007	12	7.2	11.0	120.7	2.0	1.7
2/27/2007	18	7.2	25.7	84.7	13.67	11.667
3/1/2007	20	7.2	18.3	47.3	15.67	19.667
3/5/2007	24	7.2	20.7	108.0	16.33	29
3/13/2007	32	7.2	76.7	24.0	14	19

3. Mix Liquor Suspended Solid (MLSS) and Mix Liquor Volatile Suspended Solid (MLVSS) datasheet

Dates	Sampling Days	Train 1		Train 2	Train 1		Train 2
		MLSS			MLVSS		
		Anaerobic	Aerobic	Aerobic	Anaerobic	Aerobic	Aerobic
2/9/2007	0	-	9067	8250	-	2500	3100
2/13/2007	4	-	4867	5300	-	2600	3250
2/21/2007	12	-	5300	7733	-	2933	4233
2/27/2007	18	-	5383	6100	-	3183	3550
3/1/2007	20	-	5600	7033	-	3520	3882
3/5/2007	24	-	6133	7300	-	4020	4676
3/13/2007	32	-	6733	7400	-	4600	5800

4. Settleability and Sludge Volume Index (SVI)

Dates	Sampling Days	Train 1		Train 2	Train 1		Train 2
		Settleability			SVI		
		Anaerobic	Aerobic	Aerobic	Anaerobic	Aerobic	Aerobic
2/9/2007	0	-	278	397	-	30.66176	48.12121
2/13/2007	4	-	180	260	-	36.9863	49.0566
2/21/2007	12	-	195	200	-	36.79245	25.86207
2/27/2007	18	-	180	195	-	33.33	32.23
3/1/2007	20	-	190	215	-	32.20	32.58
3/5/2007	24	-	180	230	-	30.51	34.85
3/13/2007	32	-	185	240	-	24.03	29.63