REMOVAL OF CHEMICAL OXYGEN DEMAND (COD), TOTAL ORGANIC CHEMICAL (TOC) AND TOTAL SUSPENDED SOLIDS (TSS) USING ANAEROBIC AND AEROBIC DEGRADATION OF PHARMACEUTICAL WASTEWATER

By

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FINAL PROJECT REPORT

Submitted to the Civil Engineering Programme
in Partial Fulfillment of the Requirements
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Universiti Teknologi Petronas
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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Civil Engineering Programme
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Approved:

Dr Shamsul Rahman bin Mohamed Kutty
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.

Mohammad Hizam Shah Bin Rusmi

ABSTRACT

The purpose of this study is to determine the removal of Chemical Oxygen Demand (COD), Total Organic Chemical (TOC) and Total Suspended Solids (TSS) from an influent and effluent by using a biological degradation of pharmaceutical wastewater. The selected pharmaceutical wastewater was obtained from the Safire Pharmaceuticals (M) Sdn. Bhd which is located at Bandar Baru Seri Iskandar, Perak. This project was divided by two (2) phases, Phase I and Phase II. For Phase I, the treatment system involved is only an aerobic treatment and two reactors have been used. These reactors are Reactor A (short sludge age) and Reactor B (long sludge age). The parameters involved are COD and TOC. COD is a method to measure the chemical oxygen demand equivalent of the organic material in wastewater that can be oxidized chemically using dichromate in acid solution. The Total Organic Chemical (TOC) can be used as a measure of wastewater pollution characteristics. For Phase II, both aerobic and anaerobic treatment systems were performed but the author focus only on anaerobic treatment system. The parameters involved were COD and TSS. TSS is a measure of the settleable solids and non-settleable solids in wastewater. The average differences of COD values between influents and effluents for both reactors Reactor A and Reactor B after addition of new influent (on 5 October) was 1743 mg/L and 1540 mg/L. Moreover, the percentage (%) removal of COD for both Reactor A and Reactor B were 85% and 75% respectively. The average differences of TOC between influents and effluents for both reactors Reactor A and Reactor B were 545 mg/L and 501 mg/L. In addition, the percentage (%) removal of TOC for both Reactor A and Reactor B were 85% and 78% respectively. For Phase II, the average difference of COD between influent and effluent was 834 mg/l. The percentage (%) removal of COD was 90%. For TSS, the average values for both influent and effluent were 19 mg/l and 66 mg/l respectively. There was no removal in TSS since the values of effluent were higher than influent. Additionally, after its undergoing aerobic treatment system, the results were better. This has shown that both treatment systems are the best method to treat the pharmaceutical waste water efficiently and effectively.

ACKNOWLEDGEMENTS

In the name of Allah, the Most Gracious, the Most Merciful. Praise to Him the Almighty, that in His will and given strength, I managed to complete this final year project.

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My gratitude also goes to Universiti Teknologi PETRONAS (UTP), especially Civil Engineering Department where students were trained with essential skills to excellent in theoretical and practical work. Special thanks to all the staffs and 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. They were very friendly and their never-ending supports made the project's completion a memorable one.

Last but not least, lovely thanks to all my fellow friends and especially my parents who have been a great inspiration for me to complete the project.

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CHAPTER 1

1 INTRODUCTION

1.1 Background of Study

The wastewater used in this project is collected with permission from Safire Pharmaceuticals (M) Sdn. Bhd., a pharmaceutical company which located at Bandar Baru Seri Iskandar, Perak. This pharmaceutical company is established for manufacturing of generic drugs and contract manufacturing. The influent of the Safire's pharmaceutical wastewater has high organic and inorganic matter which exceeds the permitted value of Environmental Quality Act (EQA).

1.2 Background of waste stream

Pharmaniaga Berhad is a public listed company on the main board of the Bursa Malaysia Securities (BMS) with the vision to be Malaysia's foremost integrated healthcare solutions provider, contributing significantly to improving wellness of people by providing high quality products and services. Their product can be divided into two (2) categories which are 'Prescription Drugs' (generic products) and 'Over the Counter' (non-prescription range of products). Some examples of prescription drugs are antibiotics, respiratory, allergy & immune system, etc. Generally, the pharmaceutical wastewater is contributed by the cleaning water used to clean the apparatus for producing the medicine. The officer from the Safire Pharmaceuticals has given the possible list of chemicals in wastewater which are methanol, ethanol, sodium chloride, cleaning agent(Decon 90), chloride salt, sugar, sanitization agent (sodium hypochloride), chlorine and colorization agent (Refer Appendix 3). Further, there are thousands of chemicals used in producing a medicine and this result in the pharmaceutical wastewater with high organic matters.

1.3 Objective and Scope of Study

The objective of this study is to determine the feasibility of treating Safire's pharmaceutical wastewater using anaerobic-aerobic treatment systems. The main purpose of this project is to find the effective solution for removal of Chemical Oxygen Demand (COD), Total Organic Chemical (TOC), and Total Suspended Solids (TSS) using anaerobic-aerobic degradation of pharmaceutical wastewater.

For Phase I, only aerobic treatment has been used to treat the pharmaceutical wastewater. Two (2) reactors were used, Reactor A and Reactor B. The difference between these reactors is the sludge age. Reactor A has a shorter sludge age compare to the Reactor B. The parameters involved in the analysis were Chemical Oxygen Demand (COD) and Total Organic Chemical (TOC). This is because, both COD and TOC concentration are easier to measure and provide a more rapidly indication of effluent characteristics that the 5-days BOD analysis.

For Phase II, both anaerobic and aerobic treatment systems were used to treat the pharmaceutical wastewater and the analysis parameters involved were Chemical Oxygen Demand (COD) and Total Suspended Solids (TSS). TSS is an indicator of the relative strength of the liquid; the higher the TSS concentration, the greater the strength of the wastewater. The author will focus only on anaerobic treatment system; meanwhile Mr. Hariz will be focus on aerobic treatment system.

CHAPTER 2

2 LITERATURE REVIEW

Anaerobic Treatment

Anaerobic treatment system is an effective process, especially for high strength and warm temperature wastewaters because aeration is not required, and this will lead of 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. This treatment system will be applied in the next semester (Metcalf & Eddy, 1991)

Aerobic Treatment

Aerobic treatment system treats wastewater using natural processes or bacterial process that needs oxygen. Bacteria increase in the oxygen-rich environment and break down and digest the wastewater inside the aerobic treatment unit. Bacteria consume organic matter and transfer it into carbon dioxide. Aerobic systems treat the wastewater in stages (Catherine Taylor et al, 1996).

An important factor to influences the behaviour of the bacteria is the temperature. Lower temperatures tend to slow down most biological processes, and higher temperatures tend to speed them up. The aerobic process itself creates heat, therefore proper control of the temperature needed to keep the treatment process active. Normally the aerobic system used to treat wastewater is referred to as suspended growth. The oxygen from the bubbles supports the growth of the bacteria for the digestion of the matters in the wastewater. Those matters that are not digesting will eventually turn into sludge and will settle down. (Catherine Taylor et al, 1996)

Chemical Oxygen Demand (COD)

The chemical oxygen demand (COD) test is commonly used to indirectly measure the amount of organic compounds in water. Most applications of COD determine the amount of organic pollutants found in surface water (e.g. lakes and rivers), making COD a useful measure of water quality. It is expressed in milligrams per liter (mg/L), which indicates the mass of oxygen consumed per liter of solution. (Clair N. Sawyer et al, 2003)

Chemical that been used as oxidizing agent is potassium dichromate. During the process of oxidizing the organic substances which found in the water sample, potassium dichromate is reduced (since in all redox reactions, one reagent is oxidized and the other is reduced) and forming Cr3+. The amount of Cr3+ is determined after oxidization is complete, and is used as an indirect measure of the organic contents of the water sample. (Clair N. Sawyer et al, 2003)

While handling the COD test, a so-called blank sample is required to control that no outside organic material be accidentally added to the sample to be measured. A blank sample is created by adding all reagents (e.g. acid and oxidizing agent) to a volume of distilled water. COD is measured for both the water and blank samples, and the two are compared. The oxygen demand in the blank sample is subtracted from the COD for the original sample to ensure a true measurement of organic matter. (Clair N. Sawyer et al, 2003) remember that they will change significantly with the degree of treatment the waste has undergone. (Metcalf & Eddy, 1991)

Total Suspended Solids (TSS)

Total Suspended Solids, generally referred to as TSS, is a measure of the settleable solids and non-settleable solids in wastewater. TSS, like BOD, is an indicator of the relative strength of the liquid; accordingly, the higher the TSS concentration, the greater the strength of the wastewater. As the strength of wastewater increases, greater amounts of energy are required to clean the wastewater while increasing the costs as well. (Moran et al, 1980)

TSS of a water sample is determined by pouring a carefully measured volume of water (typically one liter; but less if the particulate density is high, or as much as two or three liters for very clean water) through a pre-weighed filter of a specified pore size, then weighing the filter again after drying to remove all water. The gain in weight is a dry weight measure of the particulates present in the water sample expressed in units derived or calculated from the volume of water filtered (typically milligrams per liter or mg/l). (Moran et al, 1980)

Recognize that if the water contains an appreciable amount of dissolved substances (as certainly would be the case when measuring TSS in sea water), these will add to the weight of the filter as it is dried. Therefore it is necessary to "wash" the filter and sample with deionized water after filtering the sample and before drying the filter. Failure to add this step is a fairly common mistake made by inexperienced laboratory technicians working with sea water samples, and will completely invalidate the results as the weight of salts left on the filter during drying can easily exceed that of the suspended particulate matter. (Moran et al, 1980)

Although turbidity purports to measure approximately the same water quality property as TSS, the latter is more useful because it provides an actual weight of the particulate material present in the sample. In water quality monitoring situations, a series of more labor intensive TSS measurements will be paired with relatively quick and easy turbidity measurements to develop a site-specific correlation. Once satisfactorily established, the correlation can be used to estimate TSS from more frequently made turbidity measurements, saving time and effort. Because turbidity readings are somewhat dependent on particle size, shape, and color, this approach requires calculating a correlation equation for each location. Further, situations or conditions that tend to suspend larger particles through water motion (e.g., increase in a stream current or wave action) can produce higher values of TSS not necessarily accompanied by a corresponding increase in turbidity for the reason that particles above a certain size (essentially anything larger than silt) are not measured by a bench turbidity meter (they settle out before the reading is taken) but contribute substantially to the TSS value. (Moran et al, 1980)

CHAPTER 3

3 METHODOLOGY

This chapter will explain on the methods used through out this project. The project is divided into two phases which are Phase I and Phase II. There are three (3) parameters of the pharmaceutical wastewater to be analyzed in this project which are COD, TOC and TSS. Each parameter has its own method to be discussed here.

3.1 Phase I

There were two reactors involved in this phase, Reactor A and Reactor B (refer figure 1). Reactor A has shorter sludge age compare to the Reactor B. Sludge age is a measure of the length of time a particle of suspended solids has been retained in the activated sludge process. These reactors were used for aerobic treatment system only. Aerobic treatment system treats wastewater using natural processes or bacterial process that needs oxygen. The experimental tests involved in this phase were COD and TOC.

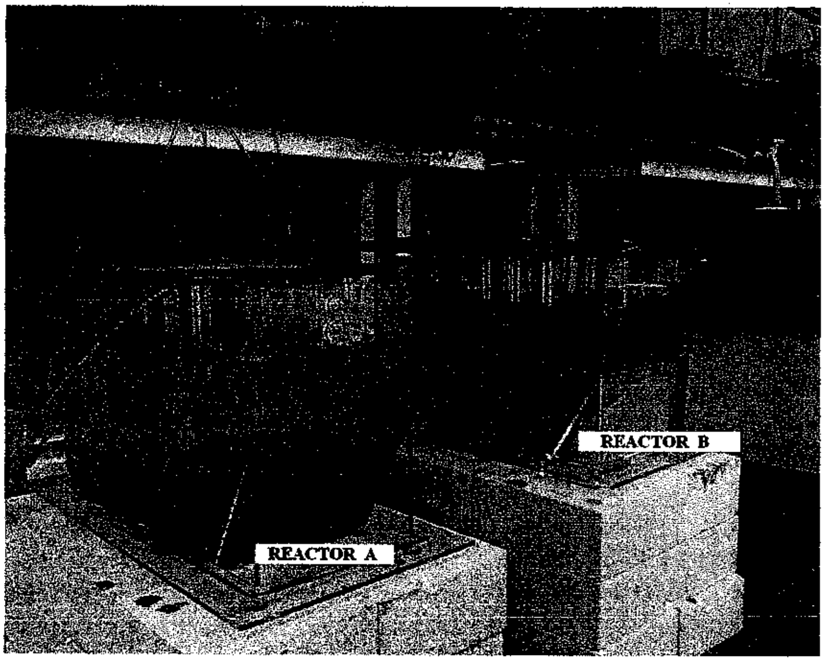

Figure 1: Phase I treatment system

3.2 Phase II

For Phase II, both anaerobic and aerobic treatment systems were applied to treat the pharmaceutical wastewater. Anaerobic treatment system is an effective process, especially for high strength and warm temperature wastewaters because aeration is not required. Aerobic treatment system needs aeration activity to produce oxygen-rich environment to increase the amount of bacteria. These bacteria will consume organic matter and transfer it into carbon dioxide. The analysis focuses only on anaerobic treatment system. The effluent point was taken between anaerobic reactor and aerobic reactor (refer figure 3). The parameters involved in this phase were COD and TSS.

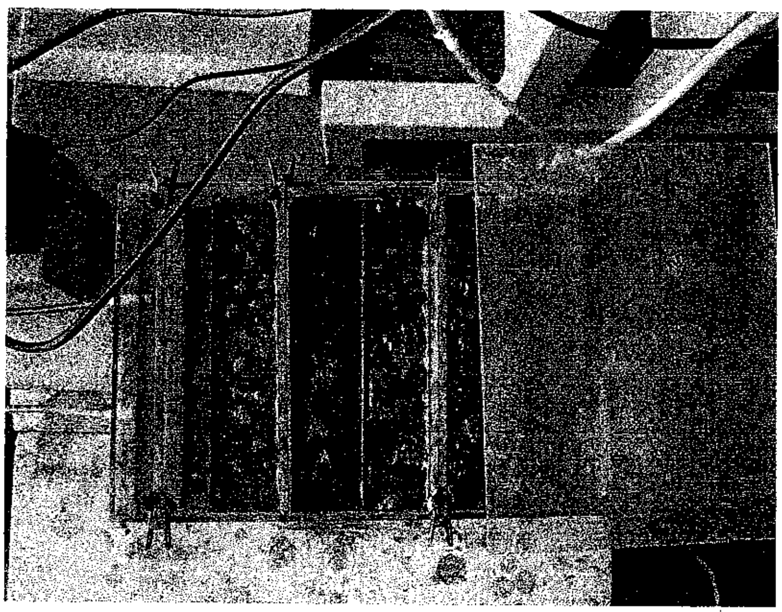

Figure 2: Plan view of anaerobic treatment system

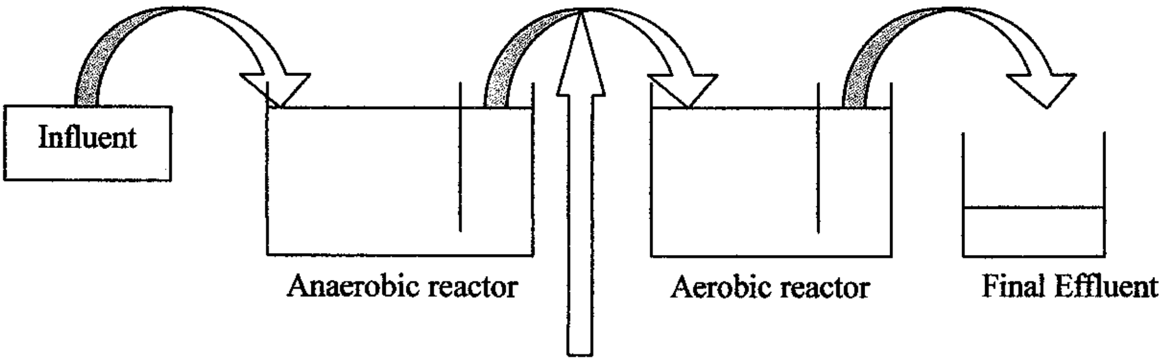

Figure 3: Phase II treatment diagram

3.3 Chemical Oxygen Demand (COD) Test

Water sample of 2 mL was taken and put it 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 are placed in the reactor for 2 hours. The samples will then be tested for COD using spectrophotometer (HACH DR 2800).

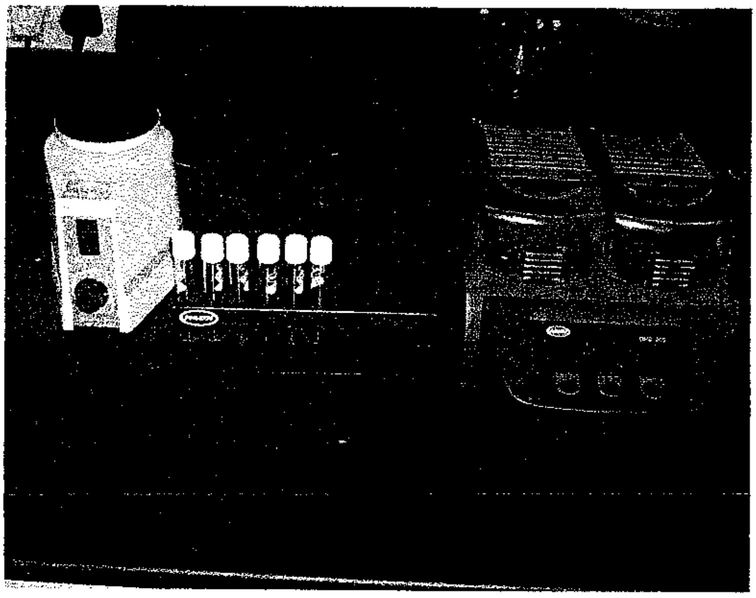

Figure 4: COD apparatus

3.4 Total Organic Chemical (TOC) Test

Turn on the COD reactor and set it into TOC condition whereby a heat was recommended in range of 103° – 105°. Graduated cylinder was needed to get an accurate measurement of 10ml of sample and pour it into Erlenmeyer flask that contains a stir bar. After that, 0.4 ml of Buffer Solution (pH 2.0) wass added. Use pH paper to make sure the sample pH is 2. Place the flask on a stir plate and stir at a moderate speed for 10minutes. Further, need to label two High Range Acid Digestion vials sample and reagent blank. Use a funnel to add the contents of one TOC Persulfate Powder Pillow to each Acid Digestion vial (colorless liquid). Then, use a TenSette Pipet to add 0.3 ml of organic-free water to the reagent blank vial and 0.3 ml of prepared sample to the sample vial. Swirl to mix. Rinse two blue Indicator Ampules (refer figure 5) with deionized water and wipe them with soft, lint-free wipe. Caution, do not touch the ampules sides after wiping. Pick them up by the top. Cap the vial assemblies tightly and place them in the COD reactor for 2 hours at 103° – 105°. Carefully remove the vial assemblies from the reactor. Place them in a test tube rack. Allow the vials to cool for one hour for accurate results. The liquid in the reagent blank vial should be dark blue.

Figure 5: Blue Indicator Ampules

3.5 Total Suspended Solids (TSS)

Place a glass fiber filter disk in filtration assembly (membrane filter funnel or clean Gooch crucible) with rough (wrinkled) side up. Then, use forceps to remove filters from storage box and to insert in filtration apparatus. Discard any filters that were torn or contain holes. After that, apply a vacuum and rinse the filter disk with three separate 20 mL portions of distilled water. When all traces of water have been removed, discontinue vacuum. Vacuum was applied and a well-mixed measured sample was poured into a filtration apparatus. After all the samples have filtrated, dry the filter in an oven at 103-105°C for 1 hour. Cool in desiccators to room temperature. Weigh glass fiber filter and support. Repeat steps until a constant weight was achieved or until weight loss was less than 0.5 mg. The cycle of drying or igniting, cooling and weighing to achieve constant weight should be performed at least one time to establish a drying time for the preparation of the glass fiber filters. The established drying time should be documented and maintained in the laboratory's permanent records. Store prepared glass fiber filters in desiccators until needed. Reweigh glass fiber filter and support immediately before use and record weight. The increase in weight of the filter and solids compared to the filter alone represents the total suspended solids (TSS).

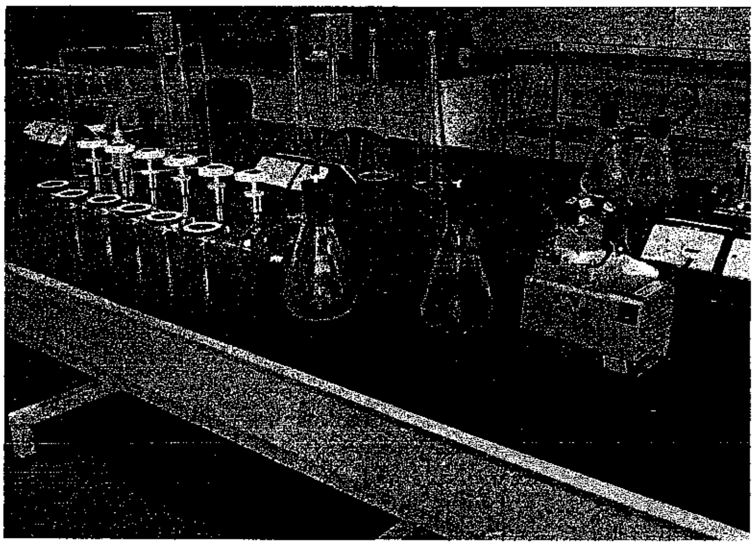

Figure 6: TSS apparatus

3.6 Setting up the Reactors

For Phase I, it took two (2) weeks to completely set-up the reactors. The reactors consist of two (2) big containers that can contain approximately 200 liters of the pharmaceutical wastewater (influent). The flow rate of the influent was 7.5 ml/minute, producing up to 10.8 liters of waste to flow to the effluent tank in one (1) day. Two (2) aerators needed for both reactors to supply oxygen. This is because within oxygen-rich environment, the bacteria will increase, break down and digest the wastewater inside the reactors. Others equipments used were two (2) bar aerators in order to distribute the oxygen effectively and to avoid settlement of the sludge and also two (2) pipes to control the flow of the wastewater into the reactors.

For Phase II, automatic pump (refer figure 8) was used to control the flow rate. The new flow rate of the raw was 5 ml/minute, producing up to around 7.25 liters of waste in one (1) day. Two (2) reactors were used to apply both anaerobic and aerobic treatment system.

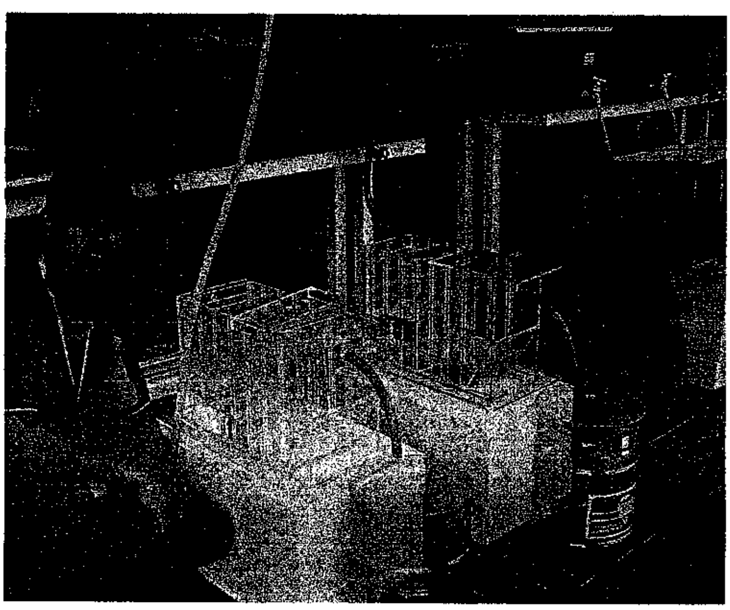

Figure 7: Complete set-up for Phase I treament

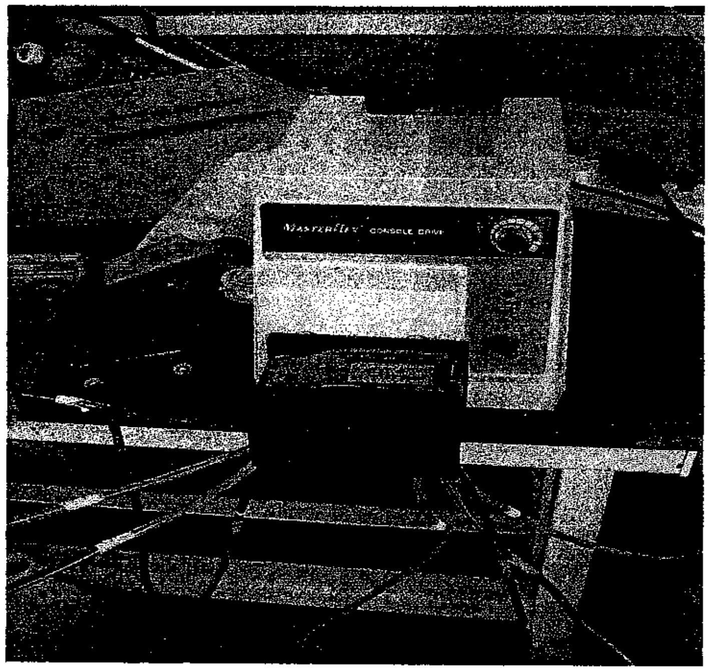

Figure 8: Automatic Pump used in Phase II treatment

Moreover, a good sampling is very important in order to get an accurate result. A sampling was occurred at influent and effluent. When to take a sample at influent, it necessary to make sure that the influent was well mix before the sample was taken. This is essential to prevent from taking a sample with different concentrated which will lead to an error in the data. For the effluent, the small container was prepared at the effluent point because the effluent will flow out from the reactors. Therefore, the sampling point for the effluent was taken from the container. Furthermore, there were essential to label all the samples with name, date and contents.

3.7 Safety precaution

In all laboratories there are certain poisonous, explosive, inflammable and irritant substances. They vary in their degree of risk but at least 75% of them are hazardous. As well as chemical hazards from sewage, and bacteria cultures. Therefore, the following safety precaution should be followed while handling the experiment:

a) Lab coat must be worn at all time.
b) All spillages must be reported immediately, whether solid / liquid and cleaned up.
c) All accidents must be reported immediately, first aid will be given.
d) All breakages large or small must be reported.
e) Return all chemicals to the preparation room immediately after use. Do not leave them lying around on the benches.
f) Take special care when handling acids and flammable liquids. Take advice on how to avoid burns and risk of fire. Use safety glasses and the fume cupboard if appropriate.
g) No mouth pippeting and hands must be washed before leaving the laboratory.

CHAPTER 4

4 RESULT AND DISCUSSION

4.1 Problem faced

Phase I

Through out the duration of Phase I, there were many problems occurred delaying the progress of our project. Generally the problems were caused by the reactor itself and this has influenced the process to obtain an effluent. Therefore, full monitoring had been given in order to minimize any possible challenges. Listed below were the major problems faced in the past 7 weeks:

4.1.1 Excess of sludge

It took weeks in order to overcome this problem. With excessive sludge, the aerators were unable to mix the pharmaceutical waste and sludge. This condition has affected the aerobic treatment system. Further, the settlement of the excessive sludge has occurred. This settlement of sludge at the bottom of the reactors had disturbed the flow of the treatment and result in overflowing around the reactors. By doing a settlebility test, a 1000 ml of wastewater and sludge mixture was taken and left to settle for 30 minutes. The result showed a 400 ml of settlement indicating too much sludge. The standard value of settleability test is around 200 ml. To overcome this problem, the content of both reactors were mixed together and 20 liters of mixture were removed. After that, 20 liters of pharmaceutical wastewater was added and this had stabilized the presence of the sludge.

4.1.2 Inadequate electrical power of aerators

The inadequate electrical power of the aerators was not good because it can affect the supply of oxygen. This caused a settlement of sludge in treatment system. Furthermore, insufficient supplement of oxygen cannot create an oxygen-rich environment to allow the bacteria to break down and digest the organic matters. Therefore, the aerators were replaced with more powerful aerators. In addition, the long bar aerators were needed instead of the short bar aerators in order to make sure the mixing process will be more effective.

4.1.3 Bubbles created by pharmaceutical wastewater

The aeration process caused the pharmaceutical wastewater to produce large volume of bubbles. According to Safire Pharmaceuticals Executive Quality Control, Mr. Ali Hanafiah, the major content of the pharmaceutical wastewater were from the detergents used to clean up the equipment. Therefore, the bubbles were caused by the presence of the detergent. After a detail monitoring, the author has made a decision to adjust the aerators' power. The power of the aerators has been adjusted to a level which can minimize the production of bubbles in pharmaceutical wastewater. Additionally, the adjusted power of the aerators used was adequate to mix up the content in the reactors.

Phase II

4.1.4 Acclimatization of new sludge

This problem occurred because of insufficient monitoring of the sludge used in Phase I treatment. The new sludge needs to be collected and acclimatize with the pharmaceutical wastewater. This stage is very important in order to make sure that the bacteria acclimatize with the influent to perform an effective treatment. The acclimatization stage consumed 2 weeks which had delayed the Phase II treatment process.

4.2 Phase I Results

There are two (2) main results for Phase I which were COD results and TOC results. The measured samples for both Reactor A (short sludge age) and Reactor B (long sludge age) had been taken at influent point and effluent point. Influent is water, wastewater, or other liquid flowing into a reservoir, basin, or treatment plant meanwhile, effluent is a treated wastewater that flows out of a wastewater treatment system.

4.2.1 Chemical Oxygen Demand (COD) Results

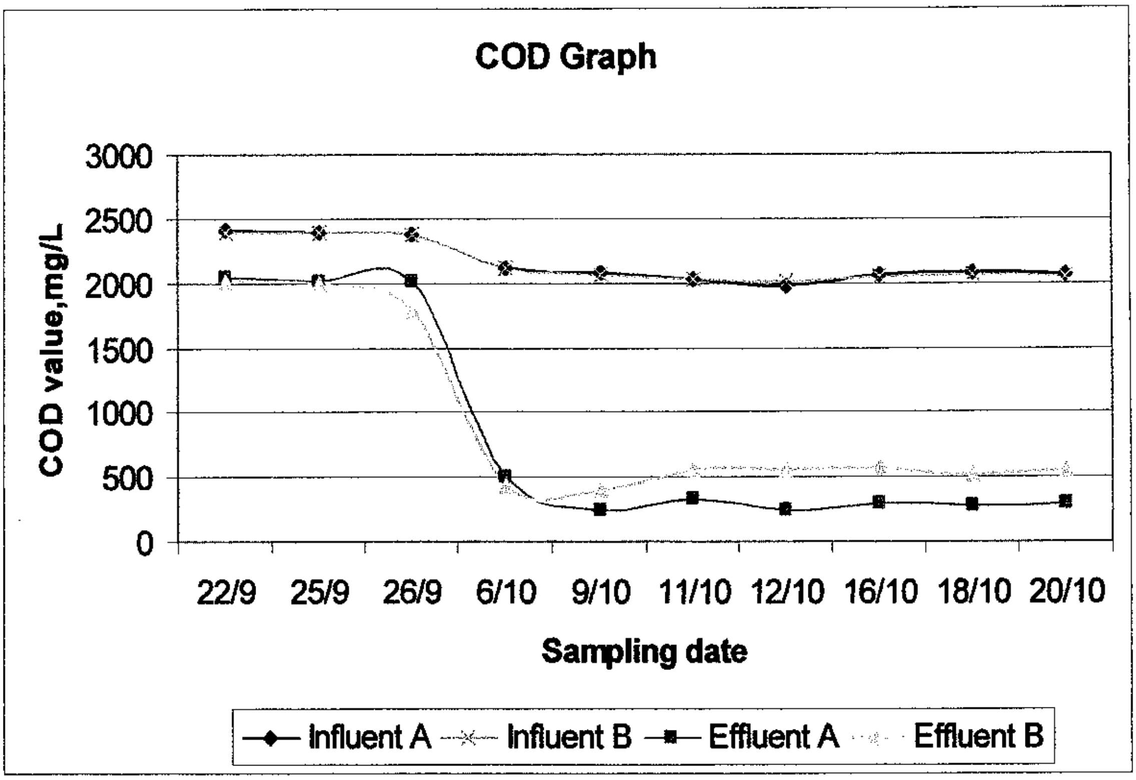

Figure 9: Removal of COD on pharmaceutical wastewater

Based on the graph above, the average values of COD on 22nd, 25th, and 29th of September for both influent Reactor A and influent Reactor B were 2391 mg/L and 2385 mg/L respectively. On the other hand, the average values of COD on 22nd, 25th, and 29th of September for both effluent Reactor A and effluent Reactor B were 2021 mg/L and 1933 mg/L respectively. The results of effluents not have too much difference with the influent values since this caused by the problems that have been stated before. On 5th of October, the new influent (pharmaceutical wastewaters) has been taken. This influent seems to be in dilution condition because on 4th October there were heavy rainfalls around the Tronoh and Bandar Seri Iskandar. Besides, the new flow rate of influent has been modified to 7.5 ml/minutes. Fortunately, with the new influent, the problems that had been faced before have been solved easily, because the main problem is the bubbles created by pharmaceutical wastewater. Coincidentally, the new influent was diluted by rainfalls therefore the treatment process can run smoothly. Even the influent was diluted by rainfalls but the COD values were constant and high. The average value of COD for both influent Reactor A and influent Reactor B after 5 October were 2057 mg/L and 2055 mg/L respectively. High COD values may occur because of the presence of inorganic substances with which the dichromate ($C_5H_7NO_2$) can react. Inorganic substances that are oxidized by the dichromate ($C_5H_7NO_2$) increase the apparent organic content of the sample. The graph shows that there are significant differences of COD values between influent and effluent after 5 October. Further, the COD values of effluent have been dropped significantly and constantly. The average values of COD for both effluent Reactor A and effluent Reactor B are 314 mg/l and 514 mg/l. Therefore, the percentage (%) removal of COD for both Reactor A and Reactor B were 85% and 75% respectively. This occurred because of the activated sludge which involved the production of an activated mass of microorganisms that capable of aerobic stabilization of organic material in wastewater.

4.2.2 Total Organic Chemical (TOC) Results

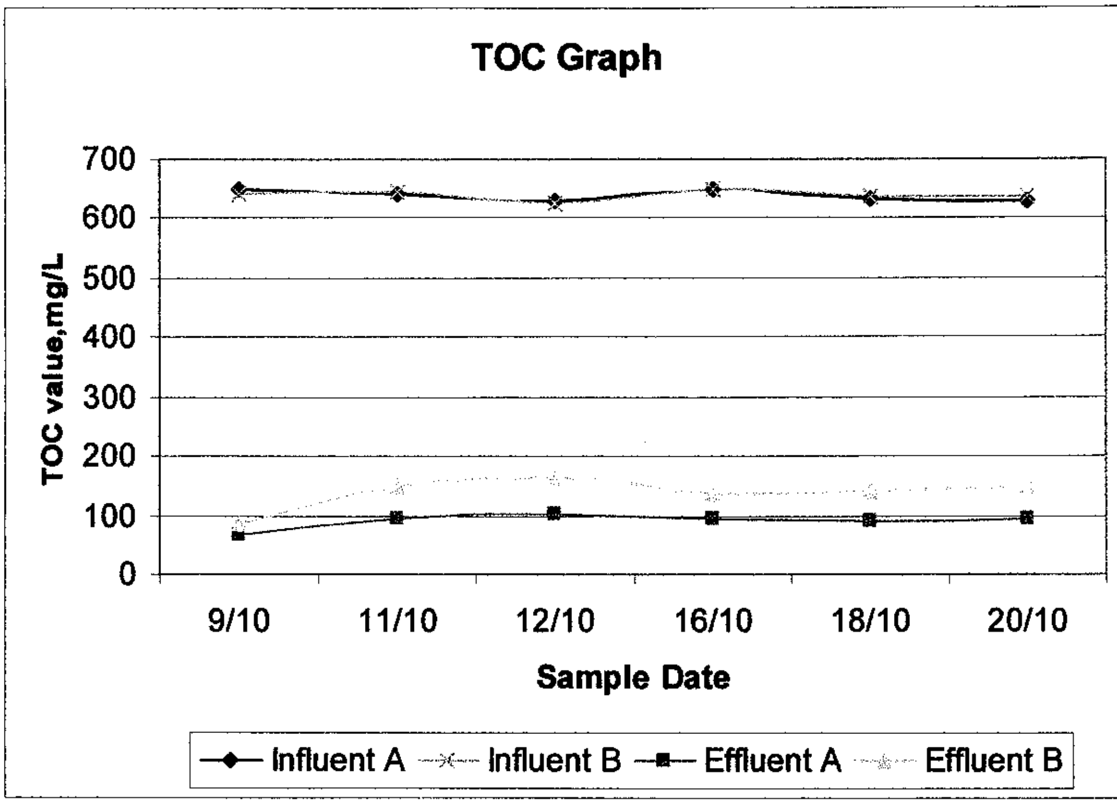

Figure 10: TOC values of pharmaceutical wastewater

From the results above, it was concluded that the TOC values for influent and effluent both were in constant condition. The average values of TOC for both influent Reactor A and influent Reactor B were 639 mg/L meanwhile the average value both effluent Reactor A and effluent Reactor B were 90 mg/l and 138 mg/L respectively. In addition, the percentage (%) removal of TOC for both Reactor A and Reactor B were 85% and 78% respectively. This shows that there are differences between the values of influent and effluent. Since the TOC of a wastewater can be used as a measure of its pollutional characteristics, therefore, it was concluded that the pharmaceutical wastewater has been treated because of the differences values between influent and effluent.

4.2.3 TOC / COD Ratio

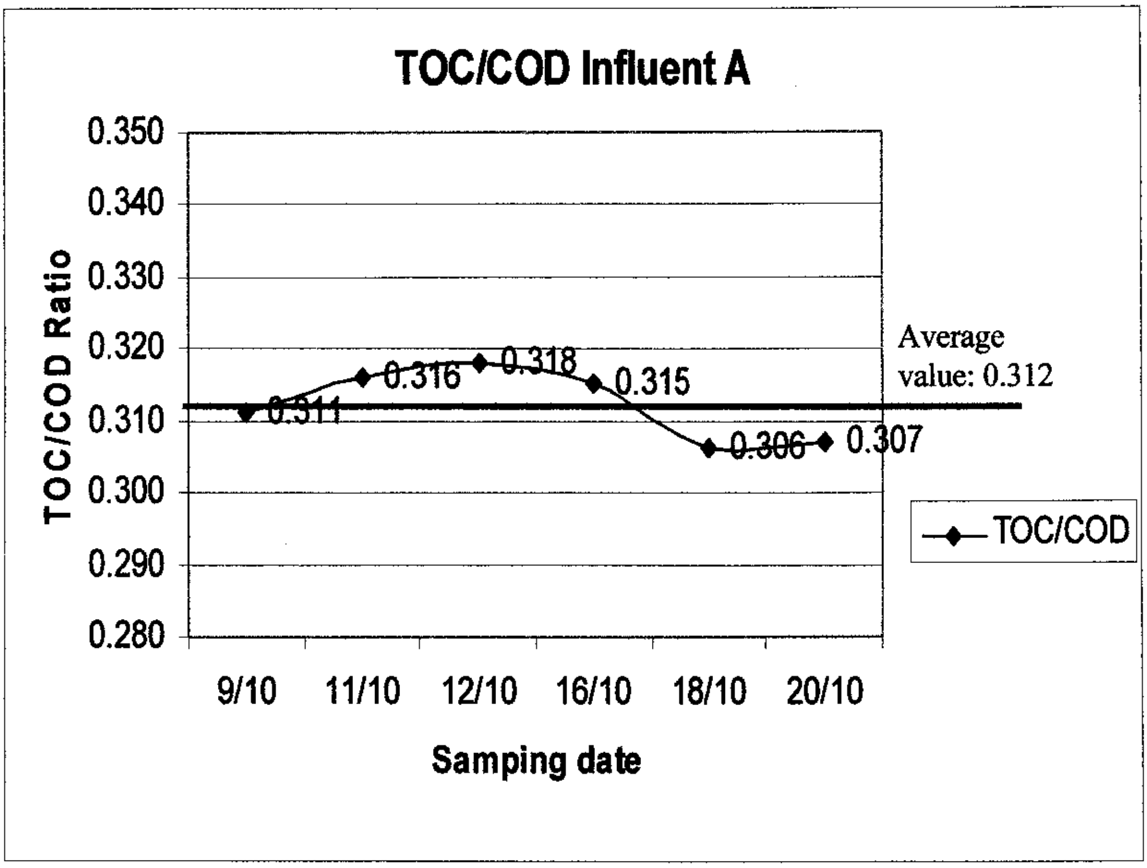

Figure 11: TOC/COD values of influent Reactor A

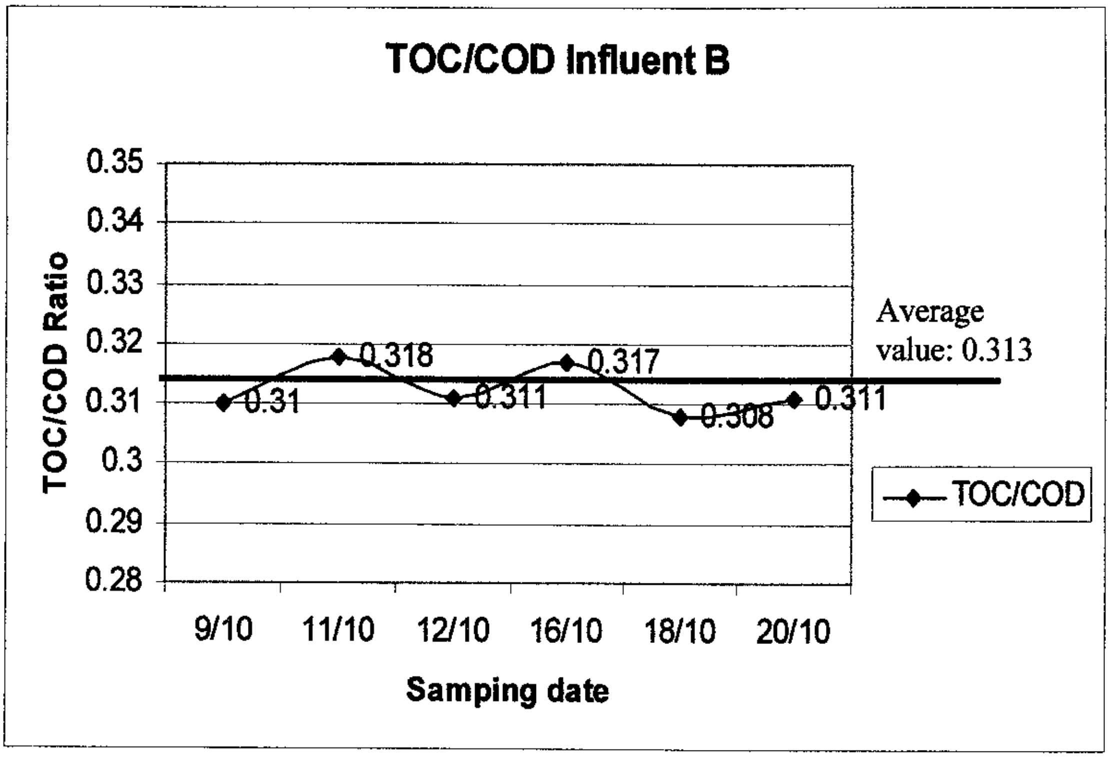

Figure 12: TOC/COD values of influent Reactor B

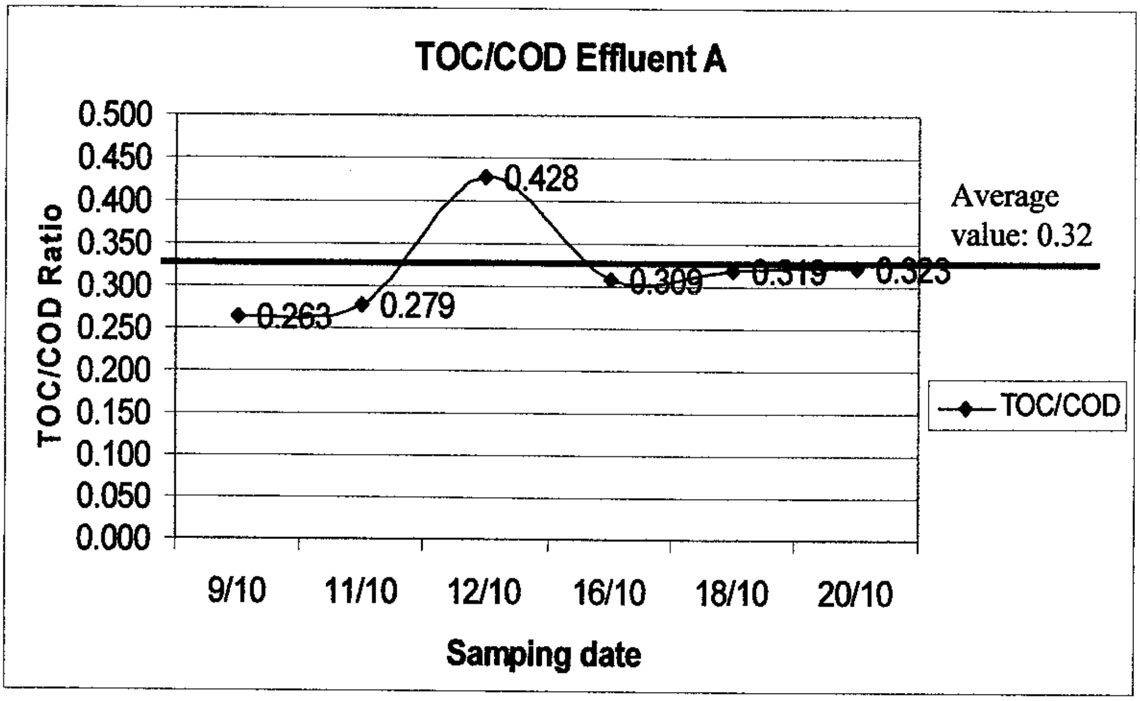

Figure 13: TOC/COD values of Effluent Reactor A

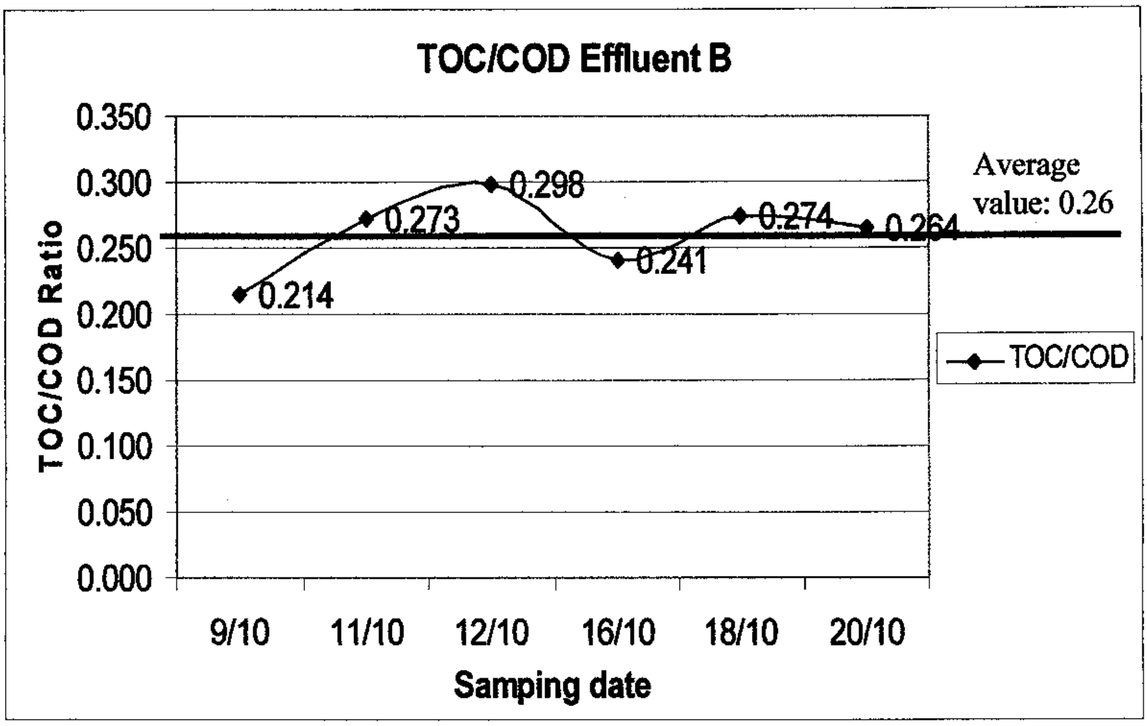

Figure 14: TOC/COD values of Effluent Reactor B

The above graphs show the interrelationship between TOC and COD. The average value for the ratio of TOC/COD for influent Reactor A and influent Reactor B were 0.312 and 0.313 (refer Figure 11 and Figure 12). The average value for the ratio of TOC/COD for effluent Reactor A and effluent Reactor B were 0.320 and 0.261 (refer Figure 13 and Figure 14).

Table 2: Comparison of ratios of various parameters for untreated wastewater

Type of wastewater	BOD/COD	BOD/TOC
Untreated	0.3-0.8	1.2-2.0

The standard typical values for the ratio of BOD/COD for untreated municipal wastewater are in the range from 0.3 to 0.8. Then, the standard typical values for the ratio of BOD/TOC for untreated municipal wastewater are in the range from 1.2 to 2.0. (Metcalf & Eddy, 1991) Therefore, after a simple calculation base on the standard value of BOD/COD and BOD/TOC, the ratio of TOC/COD for untreated wastewater is around

0.34. It can be conclude, that the values for the ratio of influent Reactor A and influent Reactor B close to the standard value. Besides, if the ratio of TOC/COD is greater than 1.0 means that organic matters have to oxidize more and if less it is vice versa.

4.3 Phase II Results

The main results on Phase II are COD results and TSS results. The measured samples were taken only at anaerobic treatment system. There were two sampling points which were influent and effluent.

4.3.1 Chemical Oxygen Demand (COD) results

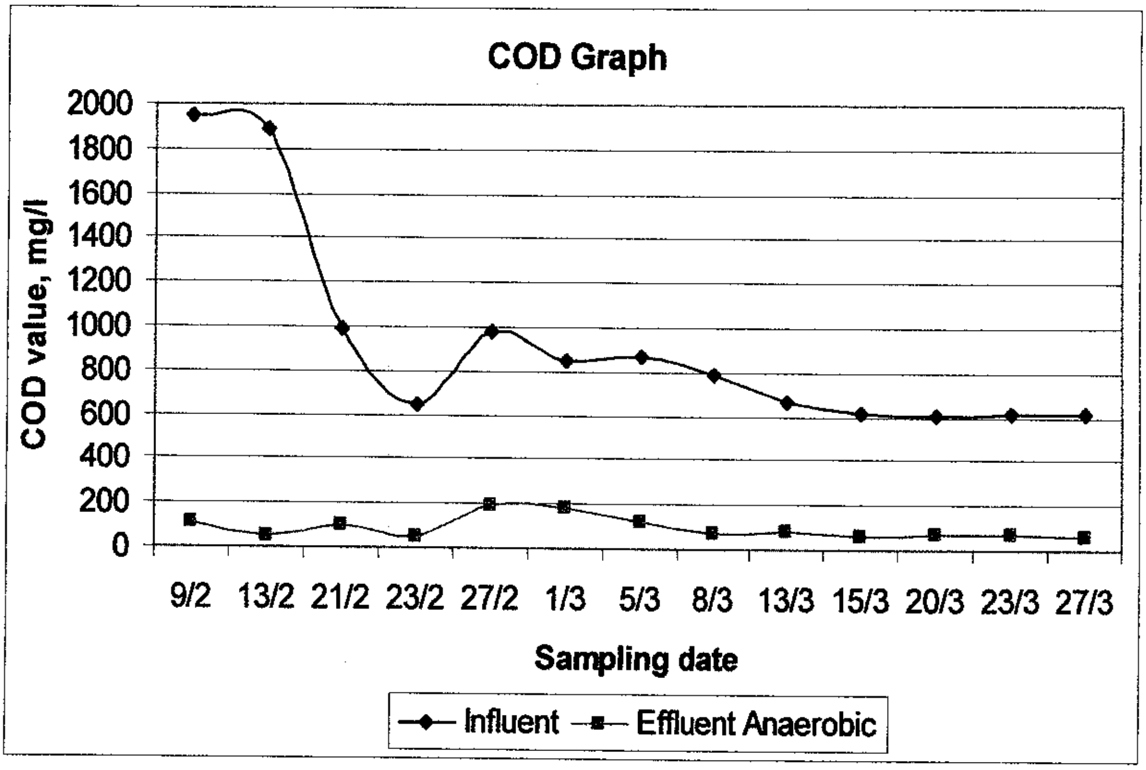

Figure 15: COD values of anaerobic reactor

This graph shows the COD results of anaerobic reactor. Based on the graph above, the average values of COD for influent was 930 mg/l. Meanwhile, the average values for effluent was 96 mg/l respectively. On 9th February, the new sample had taken from Safire Pharmaceutical and was used starting on 17th February. Towards that day, the influent's results starting on 21st of February were totally not consistent and decreasing because, according to the Safire Pharmaceuticals, the waste on that day was not in high concentration due to less production. In addition, the reactor used for anaerobic has to be changed with other reactor from other FYP student. The new rector was small in volume compare to the previous reactor and because of that the level of sludge in the reactor was close to the effluent point which has leaded the result to be poor. The average differences of COD values between influent and effluent was 834 mg/l. Therefore, the percentage removal of COD in anaerobic reactor was 90%. This show that an anaerobic treatment system was effective in removes the COD values in pharmaceutical wastewater. Furthermore, there are expected that the COD result will reach national safety level after the anaerobic effluent undergo aerobic treatment.

4.3.2 Total Suspended Solids (TSS) results

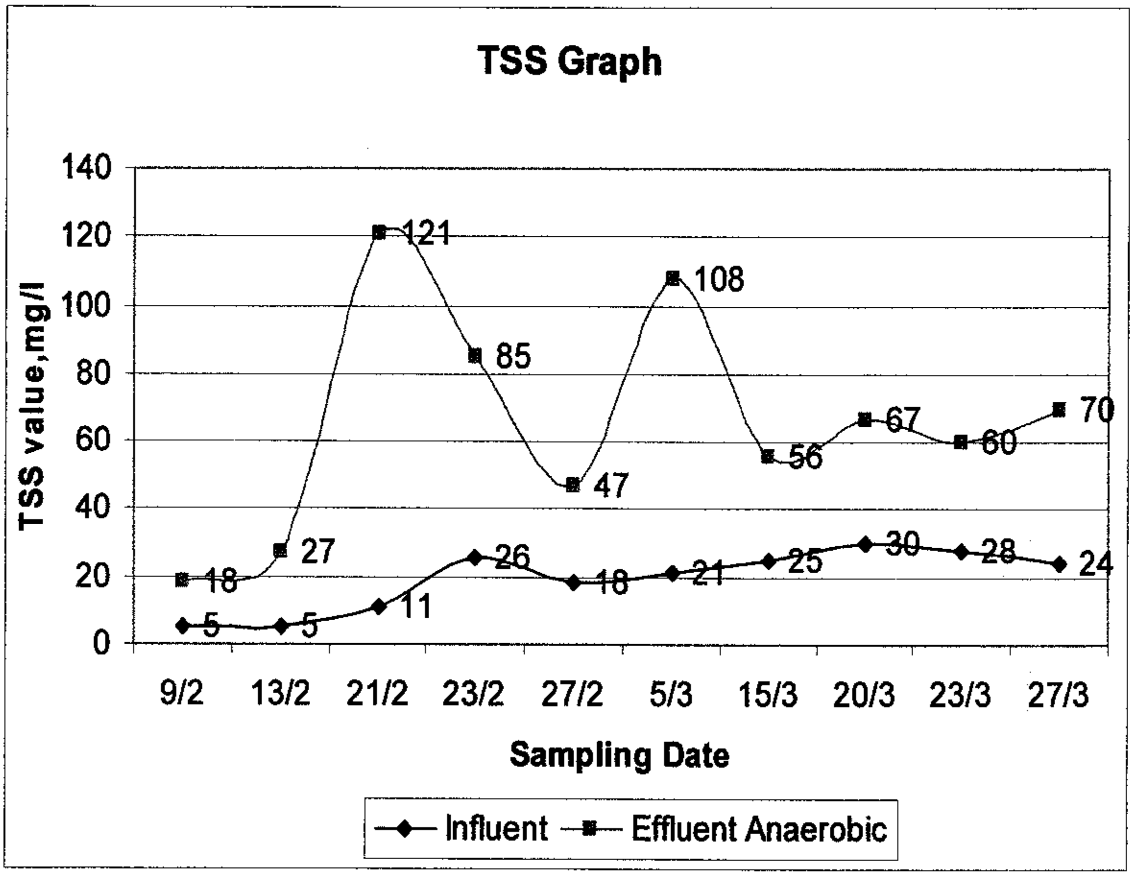

Figure 16: TSS values of anaerobic reactor

From the graph above, it shows that the average values of TSS for both influent and effluent were 19 mg/l and 66 mg/l respectively. Basically the TSS's results in effluent were higher than in influent. This was happened because of the floating particles in the effluent point. These particles have increased the total solids content and have influenced the TSS's results to be higher than influent. On 21st February, the results were too different with previous results due to mishandling equipment by junior students which had turned the oven temperature up to 300°C. This case has completely confirmed had caused the results' error by checking the blank samples. This case has happened again on 5th of March, whereby the ETP's students have used the oven to dry their specimens. The specimens were in the wet condition and had affected the result. On 13th March, the floating solids in the influent tank suddenly increases and by the author's observation, the influent's colour has turned to red. In addition, the effluent's results were expected to be better when it undergo an aerobic treatment system.

CHAPTER 5

5 CONCLUSION

Phase I

As a conclusion, the results of Chemical Oxygen Demand (COD) and Total Organic Chemical (TOC) have shown that the influent of pharmaceutical wastewater can be treated using aerobic treatment system even though the values of effluent were not exactly in safety level. The average differences of COD values between influents and effluents for both reactors, Reactor A and Reactor B after addition of new influent (on 5 October) was 1743 mg/L and 1540 mg/L. The percentage (%) removal of COD for both Reactor A and Reactor B were 85% and 75% respectively. On the other hand, the average differences of TOC between influents and effluents for both reactors Reactor A and Reactor B were 545 mg/L and 501 mg/L. Therefore, the percentage (%) removal of TOC for both Reactor A and Reactor B were 85% and 78% respectively.

Phase II

The average values of COD for both influent and effluent were 930 mg/l and 96 mg/l respectively. Therefore, the percentage (%) removal of COD was 90%. By performing excellent removal of COD in anaerobic treatment system, the final effluent will be better after undergoing an aerobic treatment system. Meanwhile, the average value of TSS for both influent and effluent were 19 mg/l and 66 mg/l respectively. There was no removal in TSS since the values of effluent were higher than influent. This has shown that, errors had occurred in TSS results because; small volume of anaerobic reactor has caused the level of sludge closer to the effluent point. Therefore, there were possibilities the sludge were gone out and affected the TSS results. Besides, floating particles wash out to the effluent point had caused to high TSS in the effluent compare to the influent. Overall, the results obtained have convinced that anaerobic treatment system had produced an excellent removal of COD. Additionally, after undergo aerobic treatment system; the results obtained will be better.

6 REFERENCE

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7 APPENDICES

Appendix 1: Table of results

Appendix 2: Illustration

Appendix 3: List of expected chemicals

Appendix 4: Pictures of bacteria

APPENDIX 1: TABLE OF RESULTS

PHASE 1

COD RESULTS (unit in mg/L)

22-Sep-06

sample	1	2	3	Average
Influent , A	2459	2378	2399	2412
Influent , B	2406	2389	2380	2392
Effluent, A	2069	2038	2012	2040
Effluent, B	1999	2008	2049	2019

25-Sep-06

sample	1	2	3	Average
Influent , A	2375	2407	2386	2389
Influent , B	2391	2370	2400	2387
Effluent, A	2041	2018	1988	2016
Effluent, B	1975	1984	2027	1995

26-Sep-06

sample	1	2	3	Average
Influent , A	2367	2371	2379	2372
Influent , B	2368	2391	2376	2378
Effluent, A	1995	1982	2042	2006
Effluent, B	1891	2046	1422	1786

6-Oct-06

sample	1	2	3	Average
Influent , A	2117	2103	2101	2107
Influent , B	2110	2114	2109	2111
Effluent, A	492	495	513	500
Effluent, B	451	447	425	441

9-Oct-06

sample	1	2	3	Average
Influent , A	2058	2083	2062	2068
Influent , B	2075	2073	2068	2072
Effluent, A	264	225	252	247
Effluent, B	412	397	410	406

11-Oct-06

sample	1	2	3	Average
Influent , A	2011	2035	2037	2028
Influent , B	2027	2021	2028	2025
Effluent, A	328	332	338	333
Effluent, B	553	551	557	554

12-Oct-06

sample	1	2	3	Average
Influent , A	1936	2007	2008	1984
Influent , B	2017	2005	2013	2012
Effluent, A	231	243	240	238
Effluent, B	544	556	558	553

16-Oct-06

sample	1	2	3	Average
Influent , A	2068	2063	2051	2061
Influent , B	2047	2038	2059	2048
Effluent, A	257	332	314	301
Effluent, B	561	568	566	565

18-Oct-06

sample	1	2	3	Average
Influent , A	2093	2071	2058	2074
Influent , B	2065	2061	2079	2068
Effluent, A	277	291	287	285
Effluent, B	527	516	521	521

20-Oct-06

sample	1	2	3	Average
Influent , A	2041	2069	2064	2058
Influent , B	2059	2045	2038	2047
Effluent, A	292	286	305	294
Effluent, B	573	559	551	561

TOC RESULTS (unit in mg/L)

9-Oct-06

sample	1	2	3	Average
Influent , A	651	649	648	649
Influent , B	638	642	647	642
Effluent, A	72	55	67	65
Effluent, B	82	92	88	87

11-Oct-06

sample	1	2	3	Average
Influent , A	641	639	643	641
Influent , B	647	642	641	643
Effluent, A	96	91	93	93
Effluent, B	147	155	152	151

12-Oct-06

sample	1	2	3	Average
Influent , A	635	624	633	631
Influent , B	628	622	629	626
Effluent, A	98	102	105	102
Effluent, B	168	161	165	165

16-Oct-06

sample	1	2	3	Average
Influent , A	639	651	658	649
Influent , B	657	638	654	650
Effluent, A	88	99	93	93
Effluent, B	143	141	124	136

18-Oct-06

sample	1	2	3	Average
Influent , A	631	635	640	635
Influent , B	644	639	629	637
Effluent, A	95	87	90	91
Effluent, B	148	140	142	143

20-Oct-06

sample	1	2	3	Average
Influent , A	635	624	633	631
Influent , B	641	633	638	637
Effluent, A	95	97	92	95
Effluent, B	148	150	146	148

PHASE 2

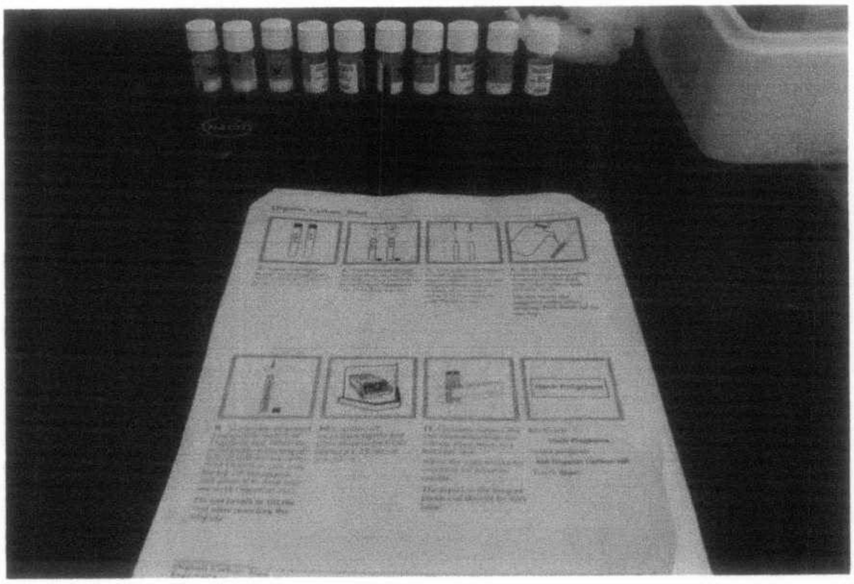
COD RESULTS (mg/L)

Dates	Sampling Days	Flow Rate Q (L/day)	Influent COD	Train 1 Effluent COD	
				Anaerobic	Aerobic
9/2/2007	0	7.2	1953	107	61
13/2/2007	4	7.2	1893	53	29
21/2/2007	12	7.2	987	104	65
23/2/2007	14	7.2	643	49	25
27/2/2007	18	7.2	978	191	191
1/3/2007	20	7.2	847	184	184
5/3/2007	24	7.2	865	126	126
8/3/2007	27	7.2	791	75	40
13/3/2007	32	7.2	670	81	32
15/3/2007	34	7.2	613	65	33
20/3/2007	39	7.2	610	70	35
23/3/2007	42	7.2	615	75	32
27/3/2007	46	7.2	620	62	31

TSS RESULTS (mg/L)

Dates	Sampling Days	Flow Rate Q (L/day)	Influent TSS	Train 1 Effluent TSS	
				Anaerobic	Aerobic
9/2/2007	0	7.2	5	18	15
13/2/2007	4	7.2	5	27	5
21/2/2007	12	7.2	11	121	2
23/2/2007	18	7.2	26	85	14
27/2/2007	20	7.2	18	47	16
5/3/2007	24	7.2	21	108	16
15/3/2007	34	7.2	25	56	15
20/3/2007	39	7.2	30	67	17
23/3/2007	42	7.2	28	60	18
27/3/2007	46	7.2	24	70	14

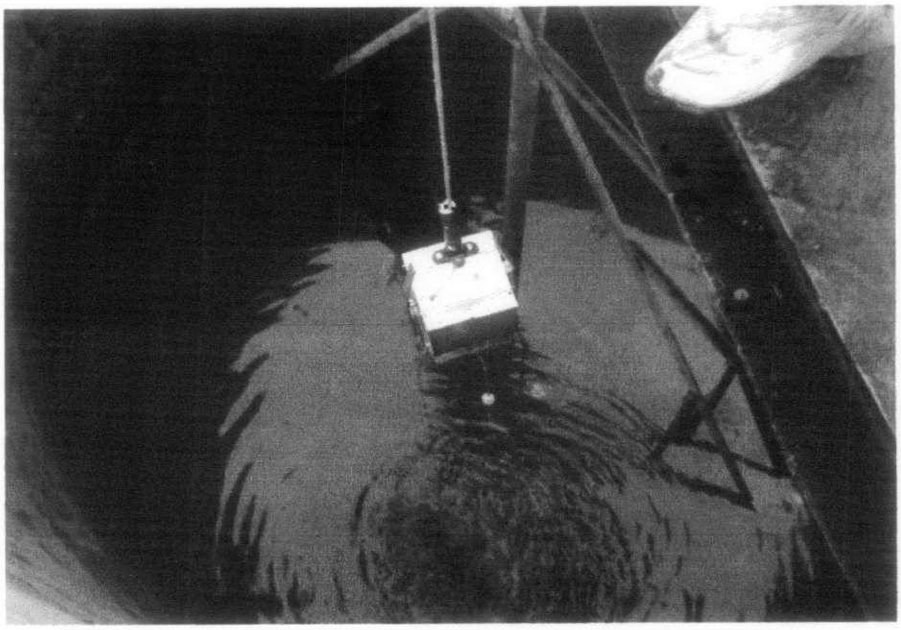
APPENDIX 2: ILLUSTRATION



TOC Test

Cleaning the apparatus used

Safety first



Taking sludge using sludge collector

Anaerobic and aerobic treatment system

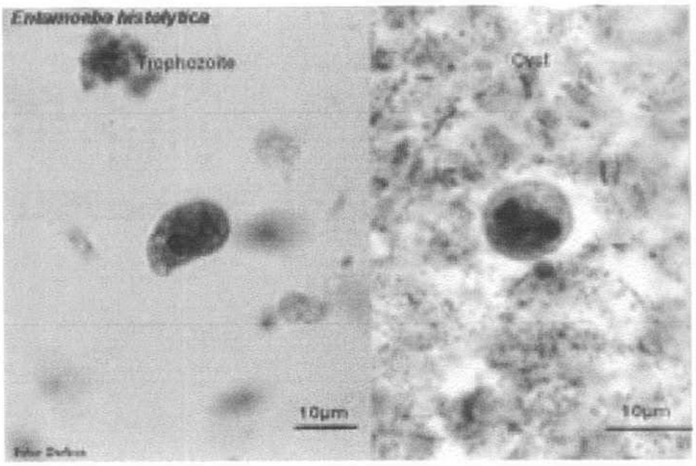
APPENDIX 3: LIST OF EXPECTED CHEMICALS

List of expected chemicals in pharmaceutical waste water:

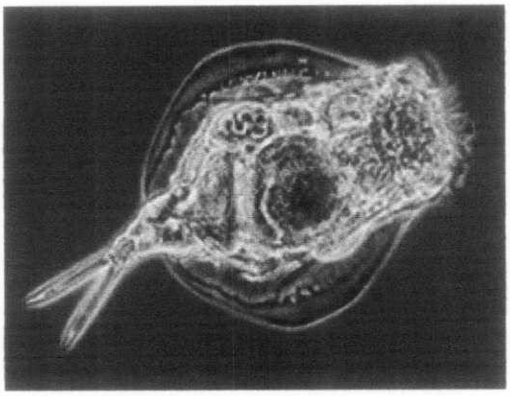
1. Methanol
2. Ethanol
3. Sodium Chloride
4. Cleaning Agent (Decon 90)
5. Sanitization Agent (Sodium Hypochloride)
6. Sugar
7. Colorization Agent
8. Chloride Salt
9. Chlorine

APPENDIX 4: PICTURES OF BACTERIA

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



ENTAMOEBA HISTOLYTICA



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(ROTIFER)