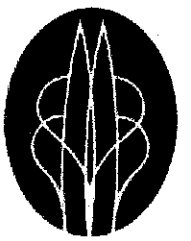

UNIVERSITI
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Organic Removal from Fertilizer Wastewater using Biological Treatment

by

Nur Saidatul Shida Sahidi

Bachelor of Engineering (Hons)
(Civil Engineering)

JANUARY 2008

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CERTIFICATION OF APPROVAL

Organic Removal from Fertilizer Wastewater using Biological Treatment

by

Nur Saidatul Shida Binti Sahidi

A project dissertation submitted to the
Civil Engineering Programme
Universiti Teknologi PETRONAS
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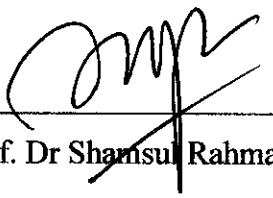
Approved by,



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Tronoh, Perak

January 2008

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.

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NUR SAIDATUL SHIDA BINTI SAHIDI

ABSTRACT

The title of this project is Biological Removal of Fertilizer Wastewater by Using Biological Treatment. The main objective of this project is to determine the efficiency of this treatment using activated sludge to remove BOD, COD and TSS that contain in fertilizer wastewater from PETRONAS Fertilizer Kedah (PFK). After treatment, the effluent will be discharged into Sg. Bongkok. The standard B is used for BOD (50 mg/L) and COD (100 mg/L).

The parameters involve are Chemical Oxygen Demand (COD) removal and Biochemical Oxygen Demand (BOD) removal.

As a conclusion, this project is to get the result till it satisfies the requirement. Then, can conclude that either this type of treatment can be used to remove BOD and COD.

ACKNOWLEDGEMENTS

Here, I would like to take this opportunity to express appreciation to those who had assisted me in completing this Final Year Project 1.

First of all, I would like to thank Assoc. Prof. Dr Shamsul Rahman Mohamed Kutty for giving me the opportunity to do the topic under him (Aerobic lagoon treatment for fertilizer wastewater). By doing this topic I can recall back what I have learned in the Wastewater Subject because I need to learn back everything about wasterwater. Beside that, I really appreciate the effort he has put into guiding and concerns me. Lastly, thanks a lot for the commitment and willingness that he put to monitor my progress for this whole semester.

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CHAPTER 1
INTRODUCTION

1.1 Background Study

For this project, the sample was taken from PETRONAS Fertilizer Kedah (PFK.) In PFK, the effluent for COD is higher, which about 136.6 ppm. In PFK also, the wastewater is placed in the stagnant pond, stagnant means not moving. Due to evaporation in that pond, the COD value had increase. In order to reduce the COD, the wastewater will be remained in that pond and aeration will be done to reduce the COD to below 100 ppm.

COD is used indirectly to measure the amount of organic compounds in water in PFK. Most applications of COD determine the amount of organic pollutants found in surface water, making COD a useful measure of water quality. It is expressed in milligram per liter (mg/L), which indicates the mass of oxygen consumed per liter of solution. The COD value also indicates the oxygen needed to oxidize all carbon compounds in sample. Typical values of COD are 500-1000 mg/L at the inlet of the plant and below 75 mg/L at the outlet of the plant. Like the other places, in PFK BOD is a measure of the oxygen used by microorganisms to decompose organic waste

Although our country has wastewater treatment plant, the main problem is it cannot be classified as world class standard. It means some compounds which can harm the environment still exist in the river although wastewater was treated by treatment plant. For example the amount of the nutrient components in fertilizer wastewater which are ammonia, nitrate and phosphorus still high in our treatment plant effluent. The main effect is the rivers become toxic to aquatic organisms and polluted to environment life.

The parameters tested on the wastewater by the PFK are pH, COD, NH_3, urea, methanol (MeOH) and formaldehyde (HCHO).

So as a conclusion, in PFK, COD is the parameters used to indicate the efficiency of the plant. This parameter is the most important ones to determine the pollution of the wastewater. Knowing these values at the inlet and the effluent of the plants make it easy to judge on the efficiency of the plant.

1.2 Problem Statement

The main problem which occurs before deciding to have this project is because PETRONAS Fertilizer Kedah effluent still has high amount of nitrogen and phosphorus compounds. This effluent can cause of eutrophication where excessive plant growth and decay and even further impacts, including lack of oxygen and severe reductions in water quality. Besides that, PFK did not test BOD. So, there is no result to refer to.

In Malaysia, there is certain place only doing the treatment of fertilizer by using aerobic and aerobic-anaerobic treatment, which is ASEAN Bintulu Fertilizer (ABF). So it is limited for me to refer any source either in local place or overseas.

1.3 Objective

The purpose of this study is to the results of fertilizer wastewater and either it is satisfied the standard of requirement or not. The objectives of this study are:

1) To investigate the removal of organic from fertilizer wastewater using Semi-Anaerobic with Aerobic System and Aerobic System.
2) To determine the removal efficiency of Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD) and Total Suspended Solid (TSS).

1.4 Scope of Study

The scope of study is to measure the effect of aerobic treatment with anaerobic and aerobic treatment using fertilizer wastewater from PFK. Since there is lack of resources regarding of this treatment for fertilizer, so that, this is a new data that will be developed and very useful to be referred to.

In this project, Biological Removal of Fertilizer Wastewater using Biological Treatment, before the raw fertilizer was flowing in; firstly need to acclimatize the sludge first. After that, the raw fertilizer (influent) is flowed into the aerobic reactor that contained of 9 L of sludge. The effluent has been collected in the basin and done the test of that effluent.

CHAPTER 2
LITERATURE VIEW

2.1 BOD And COD Removal

Diffused aeration is one of the methods in activated sludge treatment plant to increase the efficiency of BOD and COD removal. Diffused aerators add air to the wastewater and thus increase the dissolved oxygen content. This aerator supplies the oxygen necessary for aerobic biological treatment for the microorganisms. Fine bubble diffused-aeration systems are available in various types including ceramic and membranes that are highly efficient. This system offers very low volatile organic compound (VOC) stripping potential and provides good BOD and COD removal efficiency. (Steiner, Nobert, Nov.1992, p.261-264)

Biochemical Oxygen Demand (BOD) is a laboratory measurement of wastewater that is one of the main indicators of the quantity of pollutants present; a parameter used to measure the amount of oxygen that will be consumed by micro organisms during the biological reaction of oxygen with organic material. The total milligrams of oxygen required over a 5-day test period to biologically assimilate the organic contaminants in 1 litre of wastewater maintained at 20°C. The BOD5 of a wastewater is widely used as an indicator of the fraction of organic matter that may be degraded by microbial action in a given time period at a temperature of 20°C. BOD5 is a measure of the pollutional strength of a wastewater and the test is related to the oxygen that would be required to stabilize the waste after discharge to a receiving body of water. The BOD5 test has been widely used by regulatory agencies to gauge overall treatment plant performance. The BOD5 of domestic wastewater plant influent in the U.S. typically ranges form 100 to 300 mg/L. The traditional measurement of BOD5 of the plant influent, primary tank effluent, and final effluent gives the most common measure of treatment plant efficiency. The drop in BOD5 from raw influent to final effluent is usually used in calculating the solids growth rate in the aeration tank. This test is too slow to provide timely information to the operator for control purposes. It can, however, provide the operator with the historic results of previous operating decisions. Tests for BOD5 are to be made on composite samples daily. BOD tests run for at least 20 days should also be made on the

effluent periodically to determine the oxygen requirements of the nitrogen compounds present in the effluent. COD measurements are preferred for a mixed domestic-industrial wastewater or where a more rapid determination of the load is desired. The COD test will record the oxygen demand for certain industrial wastes that cannot be used readily as food by the treatment plant organisms. The COD test may be run in several hours, giving the operator a more timely measurement of what is entering the plant and how the plant is performing. (Charles L. Woodruff, 1999)

Chemical Oxygen Demand (COD) is the milligrams of oxygen required to chemically oxidize, using chromic acid, the organic contaminants in 1 litre of wastewater. COD is another means of measuring the pollutional strength of a wastewater. By using this method, most oxidizable organic compounds present in the wastewater sample are measured rather than only the more easily oxidizable ones measured using the BOD5 test. Generally, COD values will be higher than those determined with the BOD text. The reason for this difference is that the BOD5 test measures only the quantity of organic material capable of being oxidized by microbial action, while the COD test represents a more complete oxidation. The COD test has a major advantage over the BOD analysis because of the short time required - a few hours as opposed to 5 days for the standard BOD test. This advantage permits more responsive operational control of the treatment process. Typical COD values for domestic wastewater range from 200 to 500 mg/l. As the industrial content of the wastewater increases, the ratio of COD to BOD5 typically also increases. (Charles L. Woodruff, 1999)

COD Balance in the wastewater engineering field organic pollution is measured by the weight of oxygen it takes to oxidize it chemically. This weight of oxygen is referred to as the "chemical oxygen demand" (COD). COD is basically a measure of organic matter content or concentration. The best way to appreciate anaerobic wastewater treatment is to compare its COD balance with that of aerobic wastewater treatment. (Jim Field, 2002)

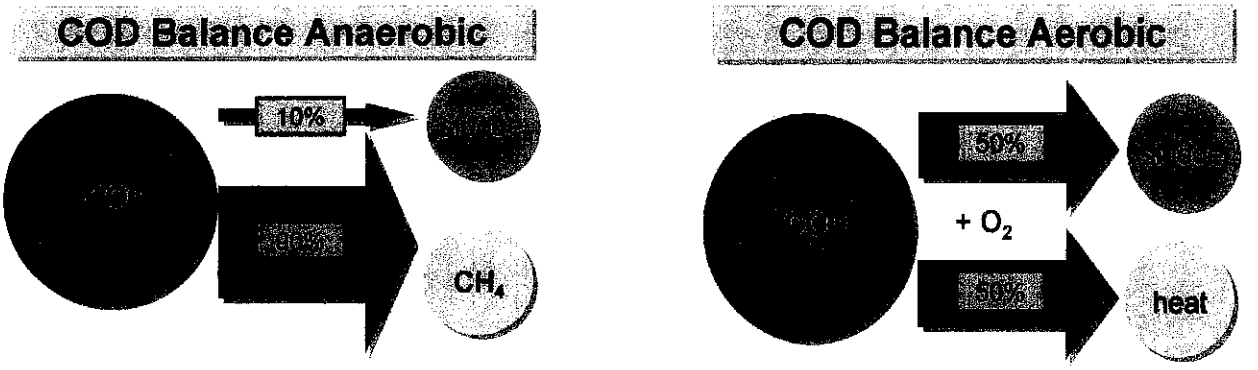

FIGURE 2.1: Comparison of the Cod Balances during Anaerobic and Aerobic Treatment of Wastewater Containing Organic Pollution

2.2 Aerobic Treatment

An aerobic treatment is characterized by aerobic conditions throughout its entire depth. It typically one to three feet in depth to allow sunlight to penetrate though out the entire water column.

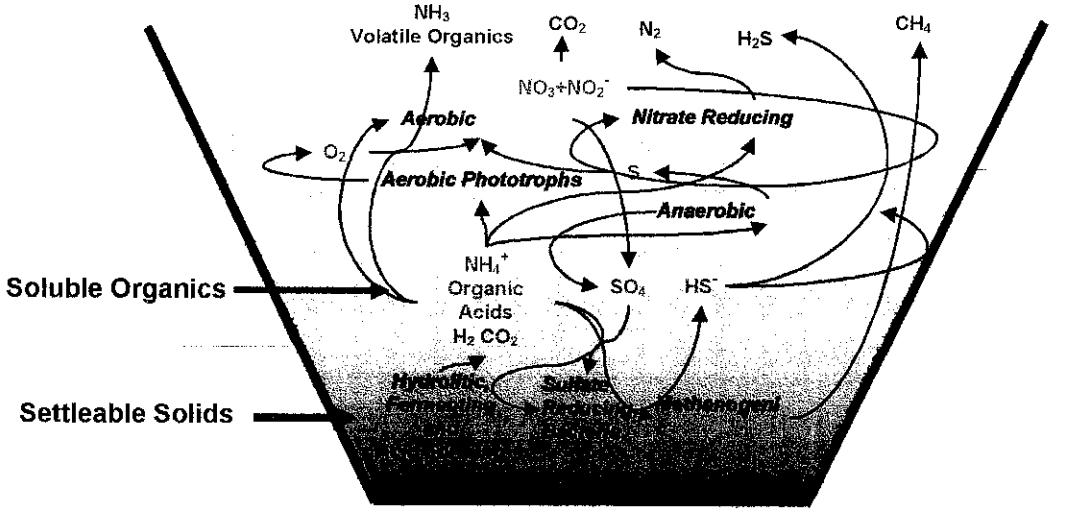

FIGURE 2.2: Conversion of Solid Organic Matter to Liquids and Gases

Aerobic digestion is a bacterial process occurring in the presence of oxygen. Under aerobic conditions, bacteria rapidly consume organic matter and convert it into carbon

dioxide. The operating costs are characteristically much greater than for anaerobic digestion because of the energy costs needed to add oxygen to the process.

Digestion is the biological decomposition of organic matter in sludge resulting in partial gasification, liquefaction, and mineralization of putrescible and offensive solids. (Charles L. Woodruff, 1999)

The main advantages of aerobic treatment are that bacterial digestion tends to be more complete than anaerobic digestion with relatively odor-free end products. In naturally aerobic treatment, oxygen diffusion occurs across the water surface. Algae also generate oxygen through photosynthesis which takes place when sunlight can penetrate the water depths. Water depths are rather shallow ranging from 3 to 5 feet. Because of the need for Oxygen transfer, naturally aerobic lagoons are designed on the basis of surface area rather than volume, are biologically lightly loaded, i.e., the organic matter added per unit volume of lagoon per unit time is very low. These typically produce minimal odors. Mechanically aerated lagoons combine the odor control advantages of aerobic digestion with relatively small surface requirements. Aerators are used mainly to control odors in sensitive areas and for nitrogen removal at limited land disposal sites. Aerated lagoons have successfully met these objectives by providing enough oxygen to satisfy 50% of the waste chemical oxygen demand (COD). Aerobic bacteria require free elemental (dissolved) oxygen. Aerated systems use either surface aerators or diffuser systems to introduce air into the wastewater and the results in consumption of the organic content of the wastewater which is mostly released as carbon dioxide.

Extended Aeration is a modification of the activated sludge process which provides for aerobic sludge digestion within the aeration system. The concept envisages the stabilization of organic matter under aerobic conditions and disposal of the end products into the air as gases and with the plant effluent as finely divided suspended matter and soluble matter. (Charles L. Woodruff, 1999)

Aeration is exposing to circulating air; adds oxygen to the wastewater and allows other gases trapped in the wastewater to escape (the first step in secondary treatment via

activated sludge process). While aerobic bacteria are bacteria that require free elemental oxygen for their growth. (Charles L. Woodruff, 1999)

Anaerobic is a biological environment that is deficient in all forms of oxygen, especially molecular oxygen, nitrates, and nitrites. Anaerobic bacteria: are bacteria that grow only in the absence of free elemental oxygen. (Charles L. Woodruff, 1999)

Mechanically aerobic lagoons use mechanical aeration to supply the oxygen needed to treat manure and minimize odors. Two kinds of mechanical aerators are used—the surface pump and the diffused-air system. The surface pump floats on the surface of the lagoon, lifting water into the air, thus assuring an air-water mixture. The diffused-air system pumps air through water, but is generally less economical to operate than the surface pump.

Aerators are designed primarily on their ability to transfer oxygen (O_2) to the lagoon liquid. Of secondary importance is the ability of the aerator to mix or disperse the O2 throughout the lagoon. Poor mixing or shutting off the aerator will result in strong odors.

Aerobic bacteria need oxygen, so the lagoon must be managed carefully to make sure that adequate oxygen is always present. Dilution water is needed from the start-up of the lagoon, and a steady daily supply of manure is required. Slug loads will quickly use up the oxygen and result in a strong odor. (George Tchobanoglous, Franklin L. Burton, H. David Stensel 2003 - 1848 pages)

Aerobic lagoons used for livestock manure have several advantages are limited or no odor from lagoon or treated manure and mechanically aerated lagoons are smaller than anaerobic lagoons.

Aerobic lagoons also have limitations, there are large land area needed for naturally aerated lagoon.high energy requirement for mechanically aerated lagoon and aerator requires regular maintenance.

Diffused aeration is defined as the injection of gas (air or oxygen) under pressure below the liquid surface. The interest in fine bubble aeration has instigated new equipment development and a multiplicity of new maintenance considerations. Field studies have demonstrated the importance of diffusers placement and tank geometry have produced more efficient system designs. Below shown the naturally aerobic lagoon :(George Tchobanoglous, Franklin L. Burton, H. David Stensel 2003 - 1848 pages)

Activated Sludge is sludge floc produced in raw or settled wastewater by the growth of zoogleal bacteria and other organisms in the presence of dissolved oxygen. Sludge particles produced by the growth of micro organisms in aerated tanks as a part of the activated sludge process to treat wastewater. Excess Activated Sludge is the quantity of sludge, surpassing that needed for proper operation, which is removed from the activated sludge system for ultimate disposal. (Charles L. Woodruff, 1999)

A well-functioning lagoon will have a neutral pH (7.0 to 8.0). If the first group of bacteria, the organic-acid formers, grows and multiplies faster than the methane formers, the pH of the lagoon can drop. If the lagoon is left untreated, it will go "sour," methane production then ceases, and strong odors are released. If the lagoon pH drops below 6.7, it is important to add hydrated lime or caustic soda—use extreme caution as these are highly reactive chemicals; consult the manufacturer's guidelines for safety procedures—daily at a rate of 1 pound per 1,000 cubic feet of lagoon volume until the pH is raised above 7. (George Tchobanoglous, Franklin L. Burton, H. David Stensel 2003 - 1848 pages)

Aerobic-facultative lagoons (or facultative lagoons) are configured as single or multiple-cell facilities. Treatment occurs through passive air-water interface transfers and photosynthetic reactions. The lower anaerobic zone of an aerobic-facultative lagoon provides sludge stabilization, volume reduction and storage. Lagoons are classified as secondary treatment facilities, although their performance in terms of contaminant removal efficiency is

often well below that of other secondary plants. (George Tchobanoglous, Franklin L. Burton, H. David Stensel 2003 - 1848 pages)

2.3 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 sludges. The organic pollutants are converted by anaerobic microorganisms to a gas containing methane and carbon dioxide, known as "biogas". (Jim Field, 2002)

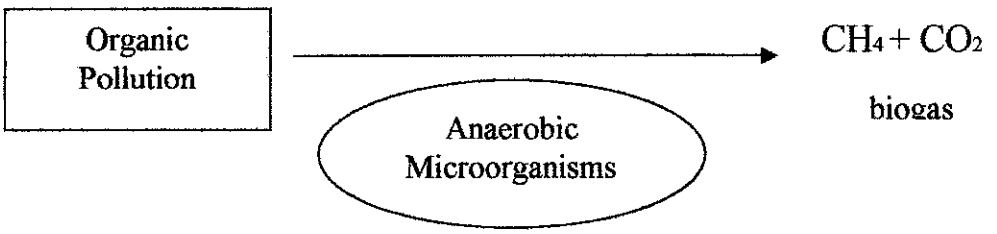

FIGURE 2.3: Conversion of Organic Pollutants to Biogas by Anaerobic Microorganisms

High rate anaerobic treatment systems refer to bioreactors in which the sludge retention time (time for sludge biomass solids to pass through system) is separated from the hydraulic retention time (time for liquid to pass through system). The net effect is that slow growing anaerobes can be maintained in the reactor at high concentrations, enabling high volumetric conversion rates, while the wastewater rapidly passes through the reactor. The main mechanism of retaining sludge in the reactor is immobilization onto support material (microorganisms sticking to surfaces, *eg.* filter material in the "anaerobic filter") or self-aggregation into pellets (microorganisms sticking to each other, *eg.* sludge granules). (Jim Field, 2002)

2.4 Anaerobic Digestion

Anaerobic digestion is a process in which microorganisms break down biodegradable material in the absence of oxygen. The process is widely used to treat wastewater sludge and organic wastes because it provides volume and mass reduction of the input material.

The digestion process begins with bacterial hydrolysis of the input materials in order to break down insoluble organic polymers such as carbohydrates and make them available for other bacteria. Acidogenic bacteria then convert the sugars and amino acids into carbon dioxide, hydrogen, ammonia, and organic acids. Acetogenic bacteria then convert these resulting organic acids into acetic acid, along with additional ammonia, hydrogen, and carbon dioxide. Methanogenic bacteria finally are able to convert these products to methane and carbon dioxide. (Ghosh, S., and D. Klass. 1977)

In an anaerobic system there is an absence of gaseous oxygen. In an anaerobic digester, gaseous oxygen is prevented from entering the system through physical containment in sealed tanks. Anaerobes access oxygen from sources other than the surrounding air. The oxygen source for these microorganisms can be the organic material itself or alternatively may be supplied by inorganic oxides from within the input material. When the oxygen source in an anaerobic system is derived from the organic material itself, then the 'intermediate' end products are primarily alcohols, aldehydes, and organic acids plus carbon dioxide. In the presence of specialised methanogens, the intermediates are converted to the 'final' end products of methane, carbon dioxide with trace levels of hydrogen sulfide. In an anaerobic system the majority of the chemical energy contained within the starting material is released by methanogenic bacteria as methane (Beychok, M., 1967).

Anaerobic Digestion (AD) is a process whereby organic waste is broken down in a controlled, oxygen free environment by bacteria naturally occurring in the waste material. Methane rich biogas is produced thus facilitating renewable energy generation. As a result, materials that are currently going to landfill can be utilised; natural methane emissions are

reduced and conventional generation with its associated carbon emissions is displaced. The residual nutrient rich liquor and digestate is suitable for use as fertiliser on the farmland surrounding such a plant, reducing the need for artificial fertilizer. (Pollock, David C, 2006)

Anaerobic decomposition is a complex process. It occurs in three basic stages as the result of the activity of a variety of microorganisms. Initially, a group of microorganisms converts organic material to a form that a second group of organisms utilizes to form organic acids. Methane-producing (methanogenic) anaerobic bacteria utilize these acids and complete the decomposition process. (Karena Ostrem, 2004)

In the thermophilic range, decomposition and biogas production occur more rapidly than in the mesophilic range. However, the process is highly sensitive to disturbances, such as changes in feed materials or temperature. While all anaerobic digesters reduce the viability of weed seeds and disease-producing (pathogenic) organisms, the higher temperatures of thermophilic digestion result in more complete destruction. Although digesters operated in the mesophilic range must be larger (to accommodate a longer period of decomposition within the tank [residence time]), the process is less sensitive to upset or change in operating regimen. (Karena Ostrem, 2004)

Anaerobic digestion is a biological process that produces a gas principally composed of methane (CH4) and carbon dioxide (CO2) otherwise known as biogas. These gases are produced from organic wastes such as livestock manure, food processing waste, etc. Anaerobic processes could either occur naturally or in a controlled environment such as a biogas plant. Organic waste such as livestock manure and various types of bacteria are put in an airtight container called digester so the process could occur. Depending on the waste feedstock and the system design, biogas is typically 55 to 75 percent pure methane. State-of-the-art systems report producing biogas that is more than 95 percent pure methane.
The process of anaerobic digestion consists of three steps. (P. Baltrėnas Et. Al, 2004)

The first step is the decomposition (hydrolysis) of plant or animal matter. This step breaks down the organic material to usable-sized molecules such as sugar. The second step is the conversion of decomposed matter to organic acids. And finally, the acids are converted to methane gas. (P. Baltrėnas Et. Al, 2004)

Anaerobic digestion is a process when the organic matter is broken down by microbes in a sealed oxygen-free environment. The process of anaerobic digestion consists of three steps. The first step is the decomposition (hydrolysis) of the plant or animal matter. This step breaks down the organic matter to usable-sized molecules, such as sugar. The second step is the conversion of the decomposed matter to organic acids. And finally acids are converted to biogas. The products of the process are biogas and compost. Biogas consists of 60–65 % of methane. Due to its high heating value gas is a valuable source of energy with a large scope of application. The biogas production is far surpassing the energy demand of the plant itself. Converted into electricity the surplus can be fed into a public network. A short aerobical treatment (a normal composting process) follows the anaerobic process. Due to its structure, a high percentage of the organic matter and its good balance of nutrients, the resulting compost has a large range of agricultural and horticultural applications. (P. Baltrėnas Et. Al, 2004)

The biogas production is a chemical process occurring in stages during which different bacteria act upon the organic matter resulting in the formation of methane and acids. The main factors that influence the biogas production are pH (the level of acidity) of the feedstock and temperature. It is well established that a biogas plant works optimally at pH level of 7 or just above (neutral solution) and at a temperature of around 35 oC. At a low temperature bacteria activity slows down resulting in substantial decrease in gas generation, ceasing completely below 10 oC.

The production of methane gas is the slowest and most sensitive step of the anaerobic digestion process because it requires specific environmental conditions for the growth of methanogenic bacteria. These bacteria can only digest effectively at a pH of 6.6-7.6, and if the growth of the acid forming bacteria is excessive, there will be an overproduction of acid leading to a decrease in the pH causing many problems. (Metcalf & Eddy, 457).

Also, the methanogenic bacteria have a limited temperature range for optimum performance, usually in the mesophilic range (90 - 105 °F). Often this requires pre-heating of the waste before entering the digester (Owen, 2003).

2.5 Aerobic Digestion

In an aerobic system, such as composting, the microorganisms access free, gaseous oxygen directly from the surrounding atmosphere. The end products of an aerobic process are primarily carbon dioxide and water which are the stable, oxidised forms of carbon and hydrogen. If the biodegradable starting material contains nitrogen, phosphorus and sulfur, then the end products may also include their oxidised forms- nitrate, phosphate and sulfate.[5] In an aerobic system the majority of the energy in the starting material is released as heat by their oxidisation into carbon dioxide and water. (Corbitt, R. A, 1990)

Composting systems typically include organisms such as fungi that are able to break down lignin and celluloses to a greater extent than anaerobic bacteria It is due to this fact it is possible, following anaerobic digestion, to compost the anaerobic digestate allowing further volume reduction and stabilization. (Corbitt, R. A, 1990)

When active sludge is kept in an aerobic environment without feed, in time a reduction of the volatile solids concentration is observed, with a concurrent consumption of oxygen. These phenomena characterise aerobic sludge digestion and are attributed to the oxidation of microbial protoplasm, which releases the energy required to maintain vital cell functions. The oxidation of cellular matter is called endogenous respiration, in order to distinguish it from the oxidation of extra-cellular organic material, which is called exogenous respiration. (Corbitt, R. A, 1990)

The advantages of using aerobic digestion, as compared to the use of anaerobic digestion include: (1) simplicity of operation and maintenance; (2) lower capital costs; (3) lower levels of biochemical oxygen demand (BOD) and phosphorus in the supernatant; (4) fewer effects

from upsets such as the presence of toxic interferences or changes in loading and pH; (5) less odor; (6) nonexplosive; (7) greater reduction in grease and hexane solubles; (8) greater sludge fertilizer value; (9) shorter retention periods; and (10) an effective alternative for small wastewater treatment plants. (Corbitt, R. A, 1990)

Disadvantages include: (1) higher operating costs, especially energy costs; (2) highly sensitive to ambient temperature (operation at temperatures below 59°F [15°C]) may require excessive retention times to achieve stabilization; if heating is required, aerobic digestion may not be cost-effective); (3) no useful byproduct such as methane gas that is produced in anaerobic digestion; (4) variability in the ability to dewater to reduce sludge volume; (5) less reduction in volatile solids; and (6) unfavorable economics for larger wastewater treatment plants. (Corbitt, R. A, 1990)

CHAPTER 3
METHODLOGY

3.1 Introduction

In this project, it can be classified into 3 sections, which are experimental setup, experimental mechanism and lastly is result analysis as stated in FIGURE 3.1. For the first stage is experimental setup, 3 reactors have been used for this project, refer to FIGURE 3.3. In this stage, all the reactors are setup appropriately in FIGURE 3.6. Then for the second stage are analytical procedures. At this stage, the mechanism can be divided into two reactors, which are semi-anaerobic with aerobic reactors and aerobic reactor. After that, the influent and the effluent from each reactor are taken for tested in the laboratory. The parameters have tested are TSS, COD and BOD. The final stage is result analysis.

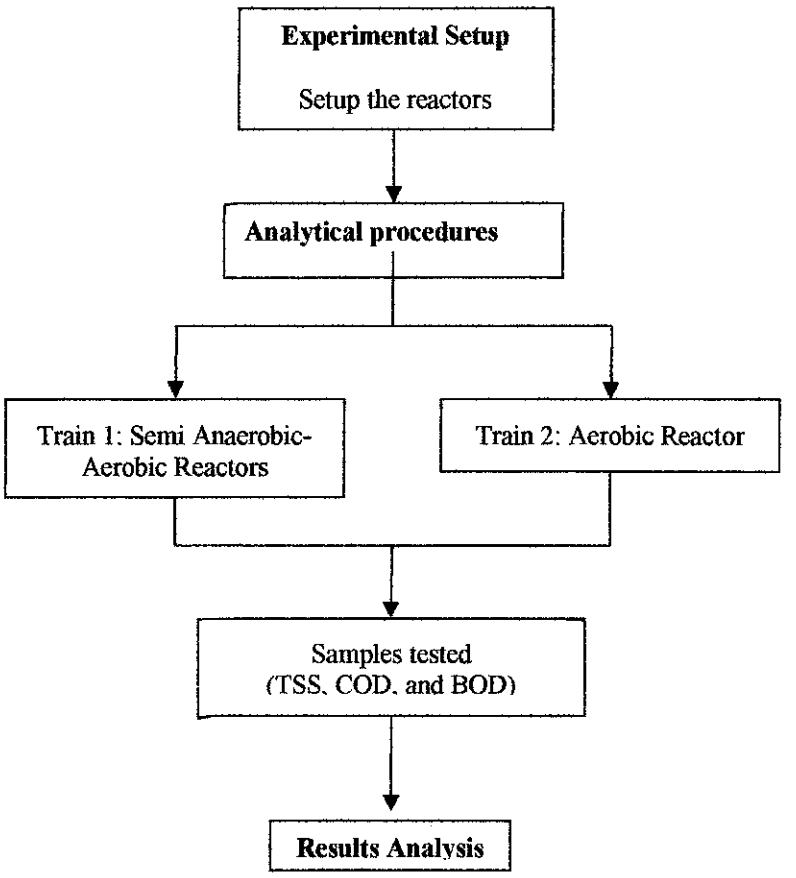

FIGURE 3.1: The Flow of Methodology

Effluent is treated wastewater, flowing from a lagoon, tank, treatment process, or treatment plant. Then, the Influent is wastewater flowing into a treatment plant. Reactor is a tank where a wastewater stream is mixed with bacterial sludge and biochemical reactions occur. (Charles L. Woodruff, 1999)

3.2 Experimental Setup

In the beginning, need to setup all the reactors according to the Anaerobic-Aerobic Reactors (Train 1) and Aerobic Reactors (Train 2), it can be referred in FIGURE 3.5 and FIGURE 3.6. Then need to acclimatize the sludge for 3 to 4 weeks before let the fertilizer wastewater flowing in FIGURE 3.7 and FIGURE 3.8. The reactors are 30cm X 20cm X 45cm. While the flow rate has been used in this project is 2.832 liter/day. The hydraulic retention time (HRT) is 6 days, it can be referred in APPENDIX 6. While Solids retention time (SRT) for Train 1 is 73 days. But for Train 2 is 43 days. The long sludge age may lead to sludge bulking.

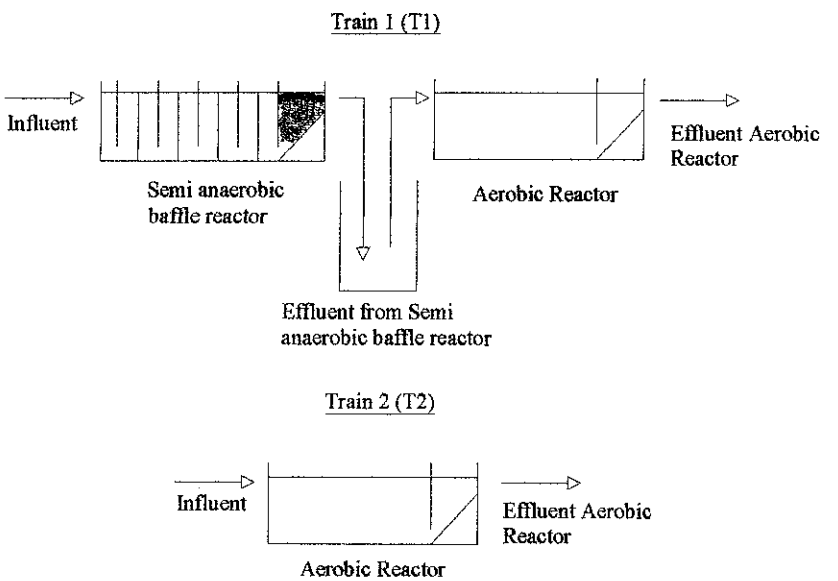

FIGURE 3.2: The Semi-Anaerobic and Aerobic Reactors (Train 1) and Aerobic Reactors (Train 2)

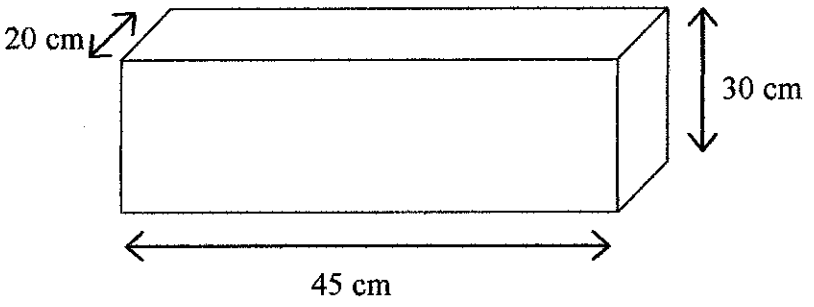

FIGURE 3.3: The Dimension of the reactor

According to the figure above, the fertilizer wastewater (Influent) is flowed into the anaerobic baffled reactor. Then, it produced effluent of anaerobic. That effluent then flowed into the aerobic reactors. Lastly, the effluent of aerobic is produced. The effluent of anaerobic and aerobic are taken as sample and tested in the lab. In the Aerobic Reactor air diffuser is used to aerate. In the anaerobic reactor, the sands and aggregated has been put into the sedimentation tank as a filter before it was flowing out.

FIGURE 3.4: The Reactors

FIGURE 3.5: The Semi-Anaerobic Reactors (Aggregates + Sand = Filter)

For train 2, the fertilizer wastewater (Influent) is flowed into the Aerobic Reactor. Air diffuser is also used in this aerobic reactor. Then, lastly it has been produced effluent of aerobic. This effluent is also taken as sample and tested in the lab.

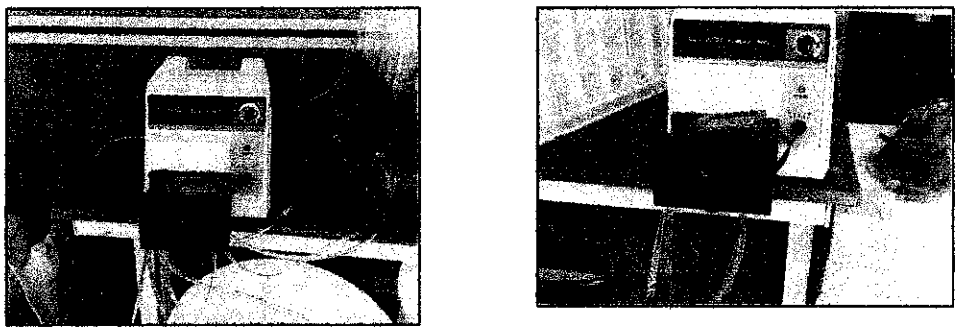

FIGURE 3.6: The Pump Used For Transfer The Fertilizer Wastewater Into The Reactors. (4 Channels)

FIGURE 3.7: Setup the Reactors

FIGURE 3.8: During Acclimatized the Sludge

FIGURE 3.9: Acclimatized the Sludge for 3 To 4 Weeks

3.3 Analytical Procedures

The parameters involved in this project are Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and lastly Total Suspended Solid (TSS). Result analysis is conducted after experimental mechanism. Sometimes the results is satisfied the requirement, sometimes it doesn't meet the requirement. So, the tests need to be conducted continuously till meet the requirement. If the result not meets the requirement till the end, need to verify why the result becomes that way.

3.3.1 Measurement of BOD

For the blank sample, during handle this blank, distilled water should have not contaminated. The value of BOD (initial – final) should not be more than 0.2 mg/L. in this project, the blank water is not contaminated. So, the blank is acceptable. If there are any changes of temperature in the BOD incubator, as the biochemical reaction rates are temperature-dependent, different results would be obtained at different temperature.

The total volume for each BOD bottle is 200mL. The 30 ml samples were added into the BOD bottle. After that, top up each BOD bottle that contained samples with distilled water. Then, the BOD before put into the BOD incubator at 20°C is measured by using the D.O meter. After the measurement, put all the samples into the BOD incubator. After 5 days, the BOD is measured again.

The biological oxygen demand which is a parameter of organic pollution can be determined. This determination involves the measurement of the dissolved oxygen used by biochemical oxidation of organic matters. But, this test has certain limitations which are a high concentration of active, acclimated seed bacteria is required, only the biodegradable organics are measured, the test doesn't have stoichiometric validity after the soluble organic matter present in the solution has been used and lastly the relatively long period of time required to obtain test results.

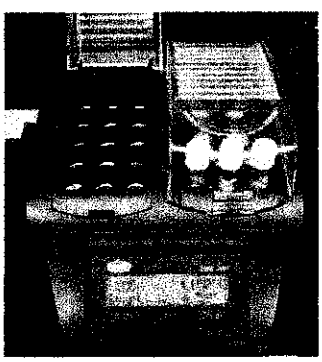

FIGURE 3.10: The Spectrometer

3.3.2 Measurement of COD

The COD test is conducted by using the standard vials that has been provided in the lab. The 2ml of distilled water is put into the vials. The, took 2ml of each sample, which are influent, effluent of aerobic train 1, effluent of anaerobic train 1 and lastly effluent of aerobic train 2. After that, put all the samples in the heater for 2 hours. The results of the samples were taken by using spectrometer, as shown in FIGURE 3.9.

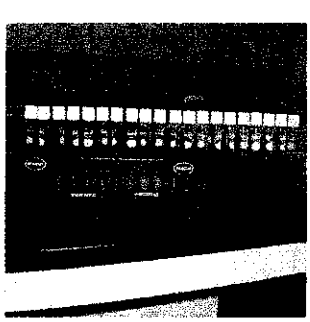

FIGURE 3.11: The Vials

FIGURE 3.12: Before Filtration

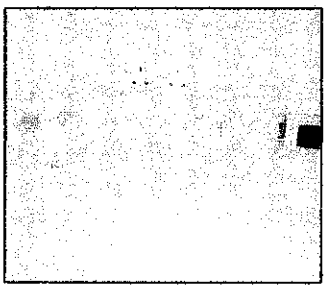

FIGURE 3.13: After Filter

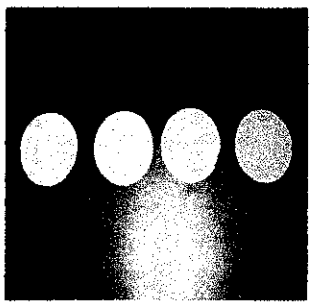

FIGURE 3.14: Color of the Filter Paper After Filtered

3.3.3 Measurement of TSS

The TSS has been conducted by filtering using the filter paper of 47μm. Total solids, or residue upon evaporation, can be classified as either suspended solids or filterable solids by passing a known volume of liquid through a filter.

For the TSS test, during handling the filter paper need to ensure that always used the tweezer. Then, the filter paper is put on the vacuum apparatus. After that, poured the samples into the

filter bottle little by little. Then put the filter paper that contained the samples into the pan and put all of it into the 105°C oven for 1 hour. After 1 hour, the readings for each samples were taken.

FIGURE 3.15: TSS Apparatus

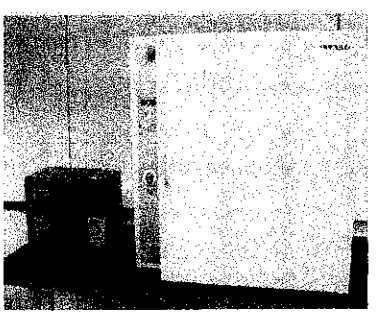

FIGURE 3.16: The oven (105°C)

3.4 Safety Measure

During handling this project, certain precautious need to be aware. In the lab, while running the tests involving chemicals and unsafe environment, some protection must be taken into consideration such as wearing PPE (Personal Protective Equipment). This PPE including wearing lab coat, goggle (safety glasses), gloves, cover full shoes and mask. The detail shown in the next page.

TABLE 3.1: FIRST AID MEASURES

EXPOSURE ROUTE	SYMPTOM	TREATMENT
Inhalation	Mild irritation of nose & throat	Remove from exposure, rest and keep warm. In severe cases, or if recovery is not rapid or complete, seek medical attention
Skin Contact	Mild irritation	Drench the skin with plenty of water. Remove contaminated clothing and wash before re-use. If large areas of the skin are damaged or if irritation persists seek medical attention
Eye Contact	Mild irritation	Irrigate thoroughly with water for at least 10 minutes. Obtain medical attention
Ingestion	Mild irritation of gastro-intestinal tract	Wash out mouth with water. Do not induce vomiting. If patient is conscious, give water to drink. If patient feels unwell seek medical attention.

Below showed the precautions need to be considered during handling the tests in the laboratory:

TABLE 3.2: ACCIDENTAL RELEASE MEASURES

Safety Precautions	Wear appropriate PPE when handling - see section 8
Environmental Precautions	Prevent entry into drains and water courses
Clean up Procedure	Bund or absorb material with sand, earth or other suitable absorbent material. If possible, transfer to a salvage tank, otherwise absorb residues and place in suitable labelled containers and hold for waste disposal - see section 13

By referring to the table below, it showed that how to handle and storage safely in the laboratory.

TABLE 3.3: HANDLING AND STORAGE

Safe Handling	Avoid prolonged skin contact. Avoid contact with eyes. Ensure good general ventilation of area. Avoid creating spray. Do not breathe undiluted vapour
Storage	Store in original closed containers Store at ambient temperature Store away from materials listed in section 10

In Table 3.4, it is showed how to reduce the accident cause in the laboratory by applying certain safety:

TABLE 3.4: EXPOSURE CONTROLS AND PERSONAL PROTECTION

Respiratory	Type approved RPE for organic vapours and mists, if required
Hand	PVC coated or rubber gloves
Eye	Goggles or face shield
Skin	Overalls and boots
Hygiene Measures	Always wash thoroughly after handling chemicals

❖ PROTECTION FOR USERS AND THE EQUIPMENT

1) Use proper techniques at all times.
2) Read all chemistry kit instructions and become familiar with the test procedure before go into the field. It is recommended that volunteers practice chemical monitoring in the home or classroom using tap water or any other readily available source of water.
3) Avoid contact between chemicals and skin, eyes, nose and mouth. Do not eat, drink or smoke while performing chemical analyses.
4) Wear safety goggles and gloves when handling chemical reagents.
5) Use the caps on test tubes when instructed to do so. Do not cover a test tube with your finger when shaking or mixing.
6) If a chemical spill occurs, follow the instructions included in the MSD sheet. Due to the small amounts of reagents in the chemical packets and because analyses are generally performed outdoors, it is not always possible to clean or recover the material. Continue to avoid, however, contact with skin, eyes, nose and mouth.
7) When performing analyses outdoors, be aware of wind direction. When measuring and adding reagents, stand with the wind to your side. This will prevent the chemical from accidentally being blown into your face.

CHAPTER 4
RESULT AND DISCUSSION

4.1 INTRODUCTION

This project was mainly involved of semi-anaerobic aerobic process (Train 1) and aerobic process (Train 2) in order to remove BOD, COD and TSS. In order to have sequenced and properly removed, the biomass should be monitored carefully and properly by observing MLSS concentration.

4.2 F/M Ratio Results

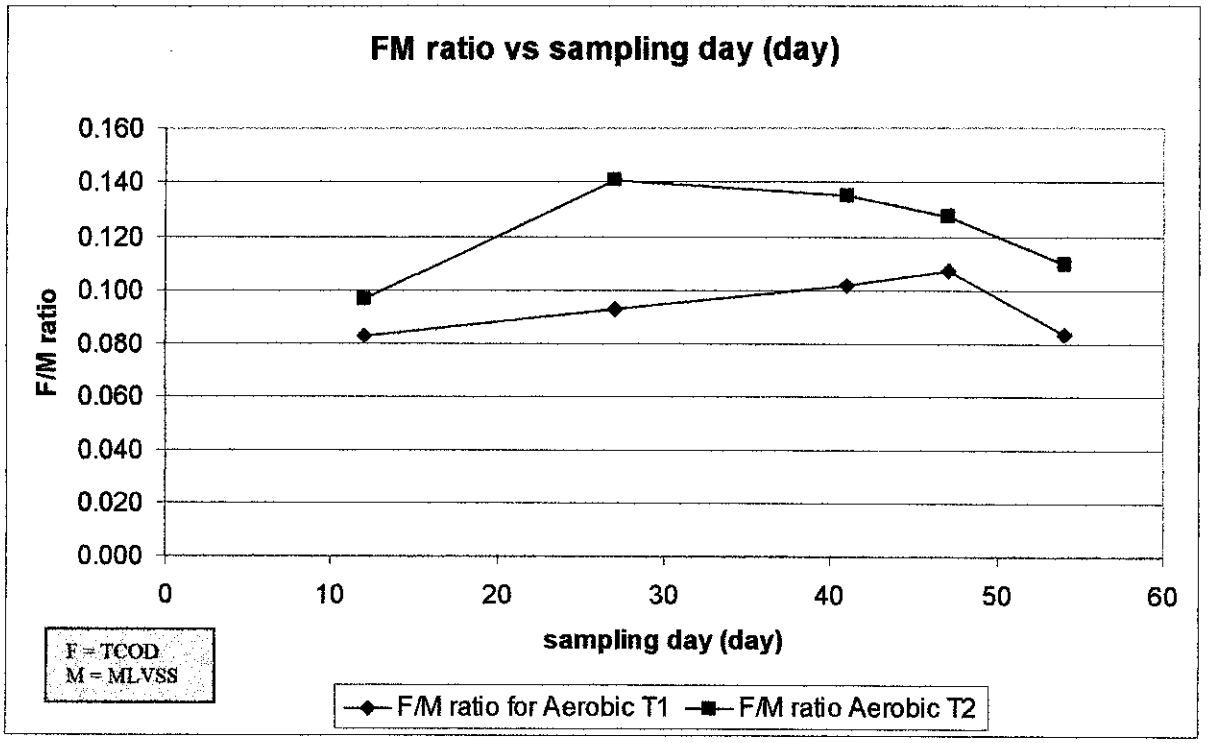

FIGURE 4.1: Graph F/M Ratio vs Sampling day for both trains

From the FIGURE 4.7, the F/M ratio for Aerobic Train 2 is increased by the time. It means that the nutrient or carbon (F) is higher than biomass/sludge (M). This situation has caused

the MLVSS of Aerobic T2 becomes lower compared to Aerobic T1. It has increased the TCOD of the Aerobic T1 effluent. In another word, the food is excess as compared to amount of bacteria. That means, the food is more than enough for Train 2. Contradictory to F/M ratio for Aerobic T2, the results of COD, BOD and TSS show optimum result. It has proved from this graph.

The F/M ratio indicates that there is a decreasing trend of F/M ratio. The aerobic reactors Train 1 and Train 2 were operated at too long sludge age. Then, the endogenous respiration might be occurred at these too long sludge age may have resulted in production of non-biodegradable COD into the effluents.

4.2.1 Microbial Analysis

The type of bacteria that has been found in Aerobic Train 1 and Train 2 are Filamentous, Aspidisca (FIGURE 4.11). When the filamentous bacteria are present in high numbers, the potential of sludge bulking occurred also higher. During observed the bacteria through the microscope there were not much moving microorganism because most of it are being degraded by other microorganisms.

Filamentous bacteria are actually excellent BOD (biochemical oxygen demand) reducers, however; the do not settle very easily forming a bridge between floc (and within floc), they have a very high negative zeta potential (high charge which will require high dosages of polymer to counter), and hold a lot of water preventing good dewatering of the sludge. They can increase polymer consumption, increase solids handling costs and can cause bulking in the clarifiers or foaming in the aeration basins. (Virginiaa Mid and Gregory D. Boardman. 1997)

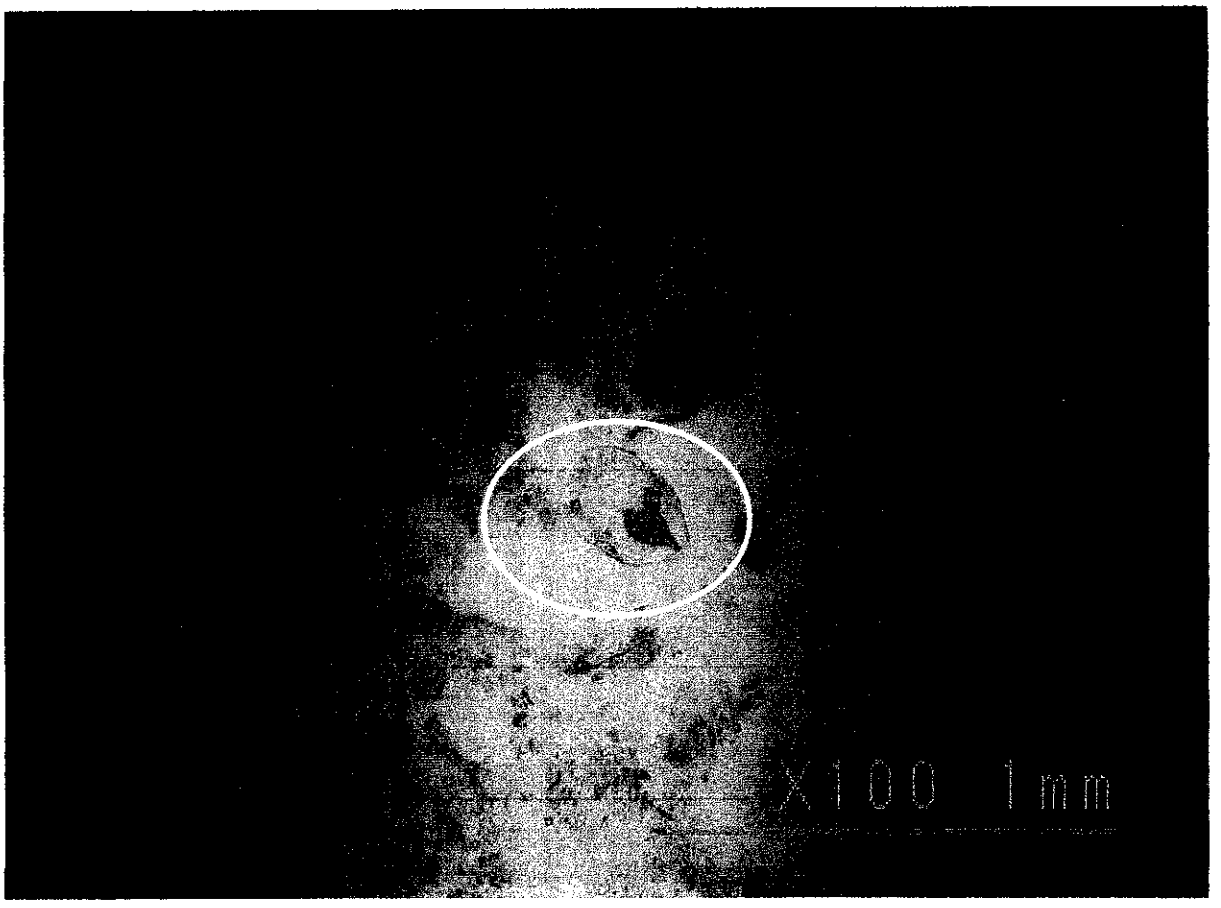

FIGURE 4.2: Aspidisca Bacteria, the Picture Was Taken In the Lab

The analysis of behaviour of *Aspidisca sedigita* has been undertaken to describe the main features of its biology. In drawing the standard ethogram of *A. sedigita*, several peculiarities have been discovered: (*i*) the cirri of *Aspidisca* are thicker and tufted versus the slim and pointed cirri of other hypotrichs; (*ii*) the side-stepping reaction is performed without its typical backward motion; (*iii*) a typical clockwise rotation of 90°, followed by a similar but anticlockwise one, is performed frequently and results in a shift of the creeping *Aspidisca* into a new trajectory, close and parallel to the previous one; (*iv*) the very rare swimming motion of the species occurs along a regular helicoid, with the ciliary organelles facing in the opposite direction of the centre of the helicoid; (*v*) the creeping and swimming of conjugating pairs are similar to those of single organisms. The analysis of behaviour of *A. sedigita* is suggested to contribute to our knowledge of the adaptive strategies of this species. (Banchetti R.; Erra F.; Ricci N.; Dini F. 2003)

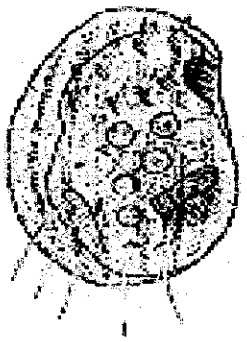

FIGURE 4.3: Aspidisca

At a first glance, *Aspidisca sedigita* prefers creeping on substrate much more than swimming, which is very rare. A second clear-cut behavioural trait of the species was its swimming, which appeared as a sort of series of uncoordinated downward tumbles. On the basis of these preliminary considerations the ethogram of *A. sedigita* was drawn and the behavioural traits of the species discussed in the general context of the ethology of ciliates The last discontinuity recognizable along the pathway of *Aspidisca* is very peculiar, consisting of a clockwise rotation of +90° followed immediately by an anticlockwise one of –90°. This motor pattern ends with a sudden jump of the cell onto a new trajectory (Ricci 1996).

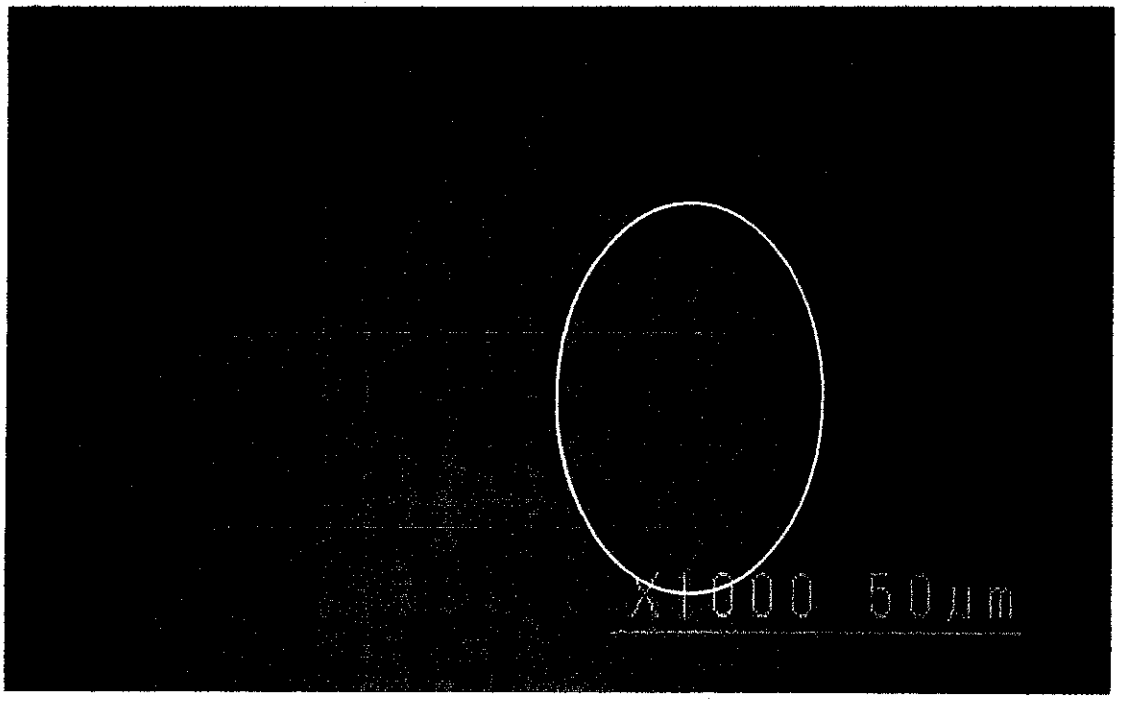

FIGURE 4.4: Spirogyra (In the Lab by Using Microscope)

Spirogyra filaments are straight, uniseriate, and unbranched. The cells are longer than broad and each contain at least one and as many as sixteen spiraled, ribbon-shaped, parietal chloroplasts with numerous round pyrenoids. The nucleus is located in the center of the cell and is suspended from strands of cytoplasm from the cell periphery. (Andrew D. Eaton et. Al, 2005)

FIGURE 4.5: Spirogyra

4.3 MLSS and MLVSS Results

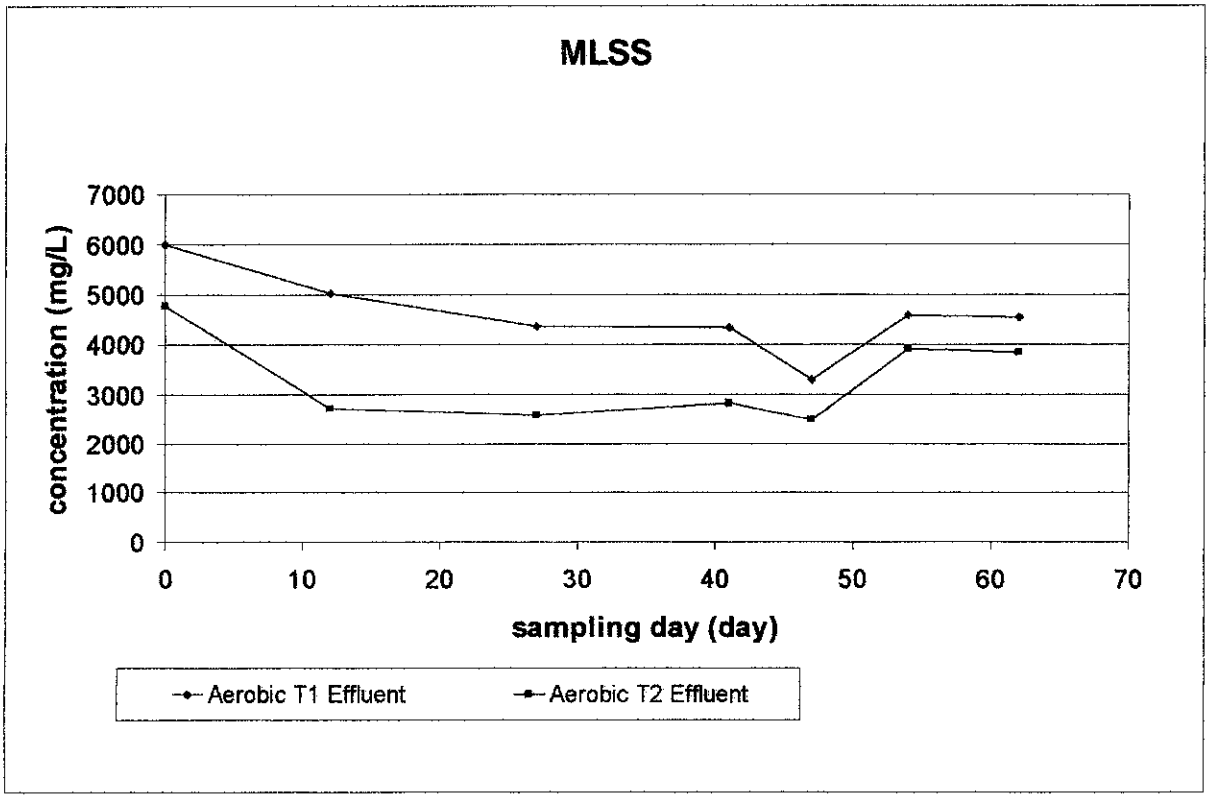

FIGURE 4.6: Graph of MLSS vs Sampling day for both trains

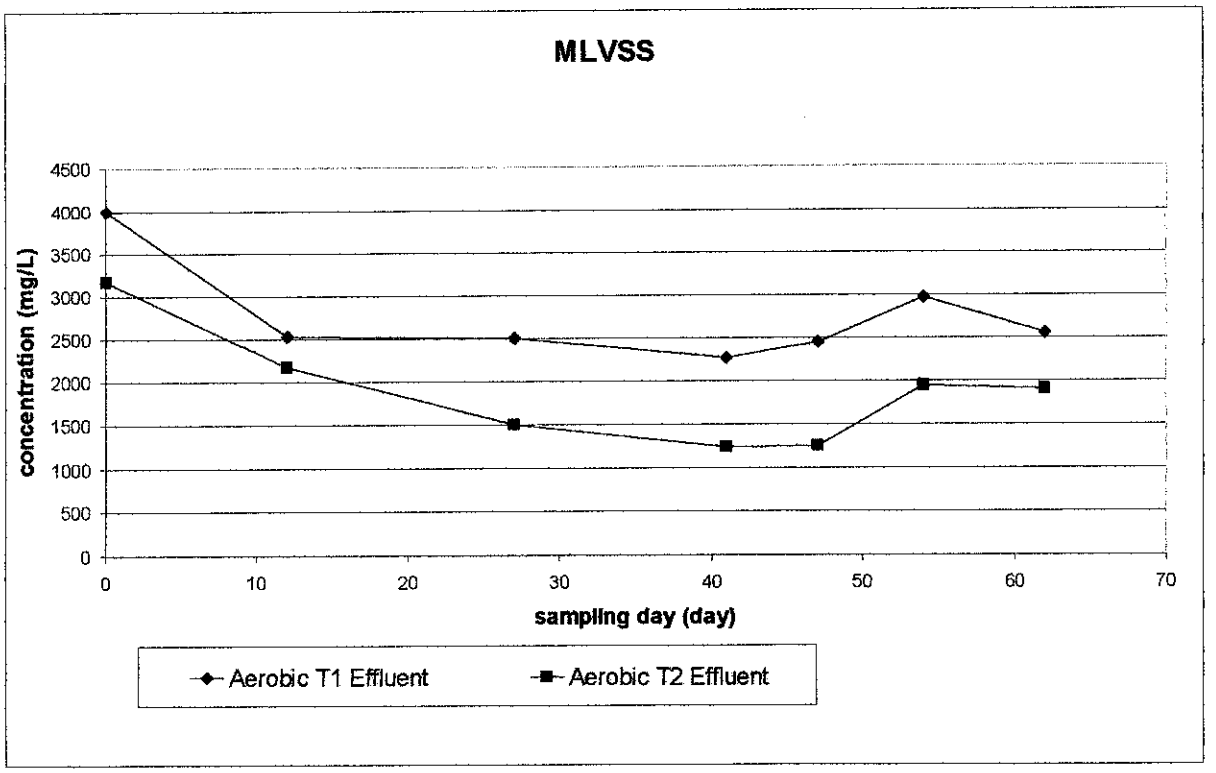

FIGURE 4.7: Graph of MLVSS vs Sampling day for both trains

The value of TCOD and SCOD in Aerobic Train 1 (FIGURE 4.1 and 4.2) are much more higher as compare to Aerobic Train 2 because the MLSS of Aerobic Train 1 is doubled the MLSS in Aerobic Train 2 (FIGURE 4.5). So, the next step is needed to ensure that the reading for Aerobic Train 1 and 2 are average 2500. According to Charles L. Woodruff, 1999, Mixed Liquid Suspended Solids (MLSS) is the milligrams of suspended solids (filtered and dries at 103°C) contained in one litre of the mixed liquor.

According to Charles L. Woodruff, 1999 Mixed Liquor Volatile Suspended Solids (MLVSS) is the milligrams of suspended solids per litre of mixed liquor that are combustible at 550°C. The value of MLVSS (FIGURE 4.6) and MLSS for Train 1 is going decrease but for Train 2 the value is going decrease and maintain around 2500 mg/L to 3000 mg/L. That is why the value of TCOD and SCOD were not too higher as Aerobic Train2.

The sludge age for both reactors very long and the biodegradable organic matter was very low. The F/M ratio for extended aeration is 0.04 – 0.1 while the MLSS is 2000 mg/L– 5000 mg/L and the SRT is 20 – 40 days.

In many cases MLSS with poor settling characteristics has developed into bulking sludge condition, which defines a condition that can caused high effluent suspended solids and poor treatment performance. In bulking condition, the MLSS floc does not compact or settle well.

4.4 TCOD Results

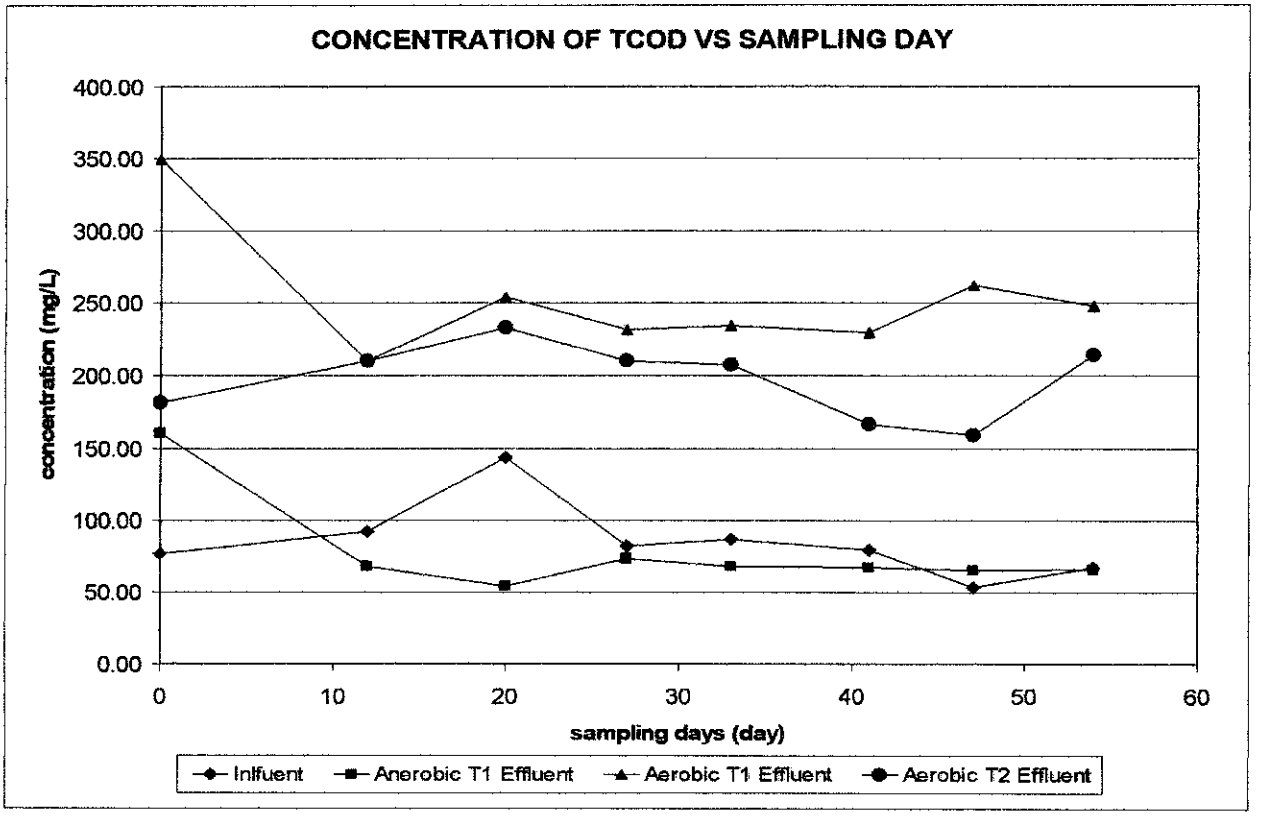

FIGURE 4.8: Graph of TCOD vs Sampling day for both trains

After the aerobic train 1 and train 2, the value of COD is getting higher as compared to COD in influent because the effluent consists of higher TSS since the biomass wasted from the reactor of aerobic Train 1 and train 2. For train 1, the color of the effluent is dark brown. It means that when the fertilizer is flowing out, it contain sludge too. Actually, there is less carbon in fertilizer wastewater. That is why the COD value of influent and anaerobic is low.

For the effluent of aerobic Train 1 and Train 2, the results is getting higher because of the biomass is not washing out, it remained in the reactor and not flowed into the sedimentation part. So, the dead microorganism is not flowing out and become bulking sludge. Then, the COD is getting higher. The COD after aerobic was higher due to accumulation of non-biodegradable end products resulting from long sludge age for both aerobic reactors. This was evident from F/M ratios which are 0.1 for Train 1 and 0.8 for Train 2.
As is was treated in the aerobic stage, effluent TCOD in Train 2 was very high due to high solids in Train 2 effluent. However, SCOD in Train 2 effluent was also higher which indicate non-biodegradable COD was produced due to long sludge age in Train 2. This was evident from the color of wastewater in aerobic reactor Train 2.

For the semi-anaerobic system, the effluent COD was found to be lower than the influent for both TCOD (FIGURE 4.1) and SCOD (FIGURE 4.2). However, there were not much removals was achieved because during anaerobic treatment the phosphorus were produced.

The hydraulic detention time (HRT) for this project is 6 days (APPENDIX 8). While the sludge retention time (SRT) is the time of the mass of biomass solids remain in the system before being wasted. When the sludge age is longer it can caused nitrification, the bacteria will eat other, or we can called it endogenous. For Train 1 the SRT is 73 days, while for Train 2 is 43 days. The sludge age is too long and the biomass undergoes endogenous degradation into non-biodegradable end products.

By referring to APPENDIX 7, since t stat > 2.14, hence reject Ho, there is significant different between TCOD for aerobic T1 Effluent and Aerobic T2 effluent. When compared the Influent with Aerobic Train 2, Ho should be acceptable since t stat < 2.14, and there is no significant different between TCOD for Influent and Aerobic T2 effluent. Same goes when comparison between Influent with Anaerobic Train 1 and comparison between Anaerobic Train 1 Effluent with Aerobic Train 1 Effluent.

4.5 SCOD Results

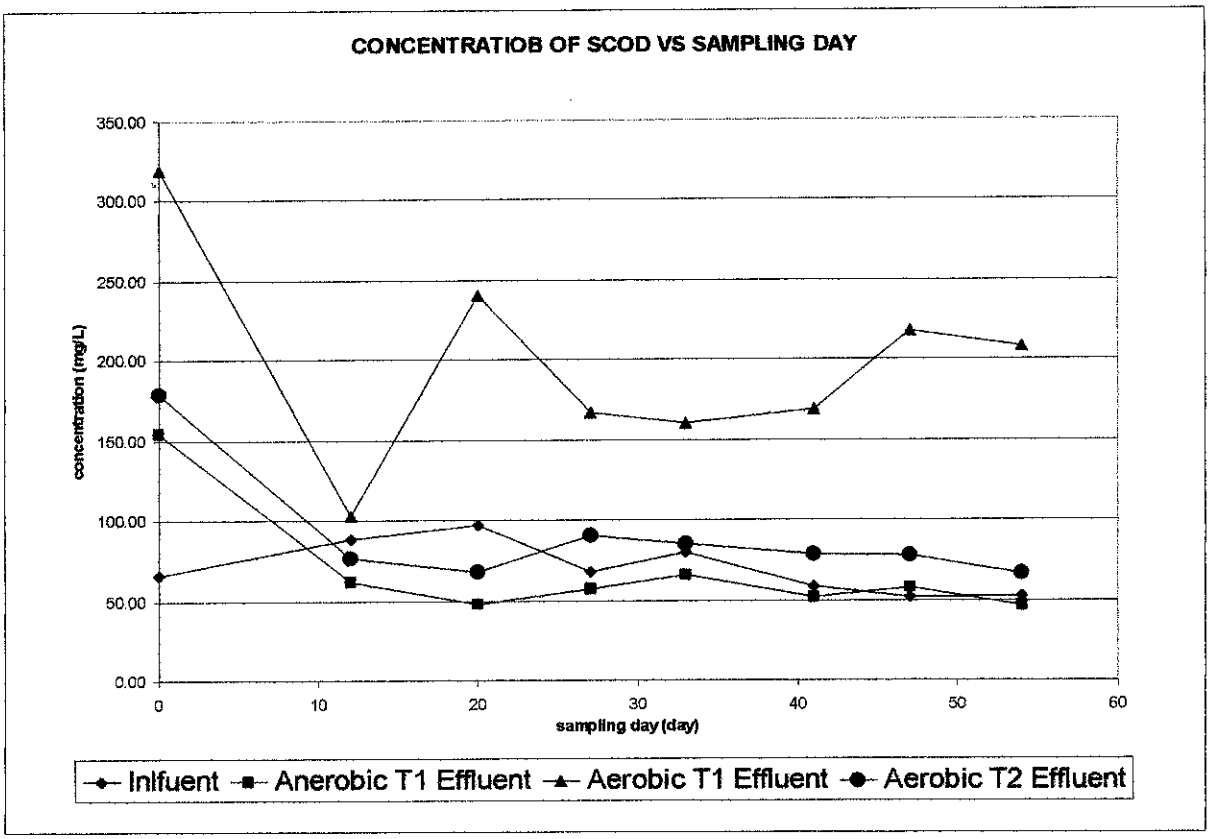

FIGURE 4.9: Graph of SCOD vs Sampling day for both trains

The value of TCOD and SCOD for aerobic train 1 is not much different; it may caused by the sludge disperse with the effluent. In order to claim that the sludge were dispersed in the effluent, the sample of effluent before and after filtration was taken, then the sample is observed using microscope. From the observation, before and after the filtrations there were bacteria existed. For train 2, the value is reasonable because the sludge in reactor is quite clear It means in term of color, its color is light brown (FIGURE 4.5). To get the lower result in train 1, we need to filter twice or put double filter paper together. So, it can remove sludge. Actually, the value of SCOD should be lower than TCOD because SCOD is we did the filtration.

In the graph, the value of SCOD for Aerobic Train 1 and 2 were increasing. So do the graph for BOD of Aerobic Train 1 and 2. TCOD and SCOD were proportionally to BOD. It means, when the value of TCOD and SCOD increase, so the value BOD also should increase. But for

Influent and Anaerobic Train 1 above, the reading is going decreasing. So the graph for BOD also decreases.

Besides that, the TCOD and SCOD in Train 1 is higher as compared to Train 2 because by referring to MLSS (Figure 4.8) and MLVSS (Figure 4.9) the bacteria in Train 1 is about doubled as compared to bacteria in Train 2.

Production of organics from anaerobic treatment also can result in high COD in effluent of anaerobic but it seems anaerobic works.

By referring to APPENDIX 11, since t stat > 2.14, hence reject Ho, there is significant different between TCOD for aerobic T1 Effluent and Aerobic T2 effluent. When compared the Influent with Aerobic Train 2, Ho should be acceptable since t stat < 2.14, and there is no significant different between TCOD for Influent and Aerobic T2 effluent. Same goes when comparison between Influent with Anaerobic Train 1 and comparison between Anaerobic Train 1 Effluent with Aerobic Train 1 Effluent. Actually, it is exactly the same with the TCOD (APPENDIX 10).

NOTE: From the left are influent, effluent of anaerobic train 1, effluent of aerobic train1 and lastly effluent of aerobic train 2.

4.6 BOD Results

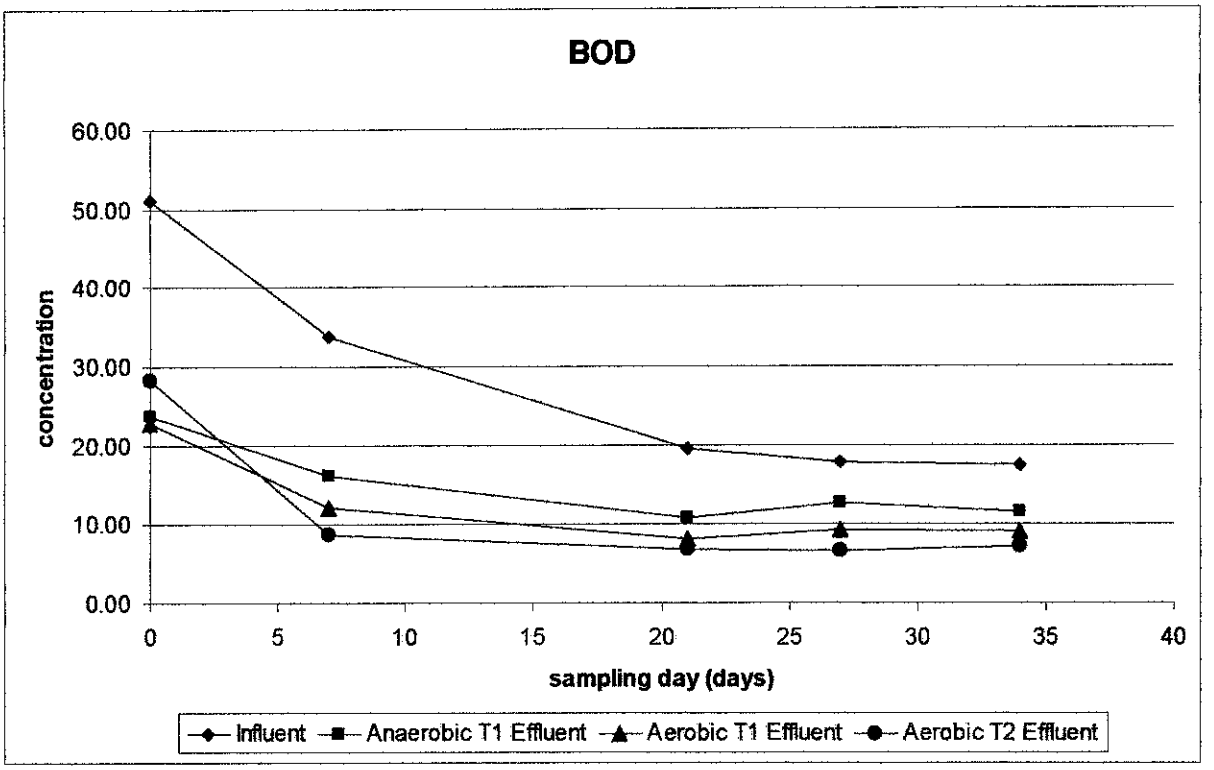

FIGURE 4.10: Graph of BOD vs Sampling day for both trains

As we referred to TCOD & SCOD graph, the value is increasing but in BOD the value is decreasing. Actually, the BOD value should be decreased too. As we know, COD is proportionally to BOD. So, to increase the value of BOD may be we need to add more sludge and TOC (Total Organic Carbon). In the aerobic train 1 and train 2, there was too much bulky sludge. The value of BOD is getting lower because TSS used BOD (in aerobic train 1 and train 2). The value in effluent Train 1 and 2 is getting lower because nitrification is occurred. The nitrification can occurred with presence of oxygen. In this process, two bacteria are involved which are nitrosomonas and nitrobacter. In many biological treatment plants, the facility effluent contains large number of nitrifying organism which is developing during the treatment process. These organisms exerted oxygen demand as they convert nitrogenous compound (ammonia and organic nitrogen) to more stable forms (nitrites and nitrates). So at least part of these oxygen demand is measure in BOD. BOD is relies on measurable depletion on DO over specific period of time.

From this experiment, the blank sample is not contaminated as the DO reading is below than 0.2 *mg/l*. As the blank sample only contain distilled water, if the amount of DO reading is higher than 0.2 *mg/l* (which is used to encounter for any air bubbles), it shows there is an existence of bacteria. The graph BOD vs. Sampling Day (day) is plotted in FIGURE 4.3.

The BOD blank (a BOD bottle full of dilution water containing only the required nutrients, but not any seed) must not show a DO, or dissolved oxygen, depletion of more than 0.2 mg/L after the five day incubation period. A drop of more than 0.2 mg/L indicates some type of contamination or calibration error. Ideally, sample dilutions should show about a 50% DO decrease after the 5-day incubation period. At a minimum, there should be at least a 2.0 mg/L DO change between the initial and the final reading. There should also be a residual DO of at least 1.0 mg/L. (Tim Loftus, 2003)

In the anaerobic reactor, the BOD is higher maybe because of the algae growing up in the reactor as compared to aerobic in train 1. So, the DO is higher too. That is why the BOD in effluent aerobic trains 1 also higher because it flows from anaerobic then flows into the effluent anaerobic train 1 (contain higher DO).

If there is a large quantity of organic waste in the water, there will also bacteria present working to decompose the organic waste. In this case, the demand for oxygen will be high (due to the all bacteria) so the BOD level will be high. As the waste is consumed or dispersed through the water, BOD level begin to decline. Actually, in sufficient soluble BOD can caused sludge bulking.

Actually, no nitrification inhibitor was used in the experiment. Hence the BOD viewed maybe due to the oxygen uptake during degradation of organic matter and during nitrification process. This is because in the wastewater sample ammonia was present.

Filamentous bacteria are actually excellent BOD (biochemical oxygen demand) reducers, however; the do not settle very easily forming a bridge between floc (and within floc), they have a very high negative zeta potential (high charge which will require high dosages of polymer to counter), and hold a lot of water preventing good dewatering of the sludge. They can increase polymer consumption, increase solids handling costs and can cause bulking in the clarifiers or foaming in the aeration basins. (Virginiaa Mid and Gregory D. Boardman. 1997)

Bubbles in a BOD bottle also invalidate that bottle's DO measurement. Algae in a BOD sample and left out on a lab bench exposed to sunlight can be a source of bubbles. Always put the BOD bottle in a dark incubator soon after the initial DO is measured and the bottle sealed. But a more common source of bubbles is from dirty glassware. Even though we should try to fill BOD bottles with sample and dilution water as bubble free as possible, there seems to always be tiny bubbles generated. If the glassware is not thoroughly cleaned, then the bubbles stick to the side of the glass and will eventually collect near the bottle's seal during the five-day incubation period. (Tim Loftus, 2003)

Another source of bubbles can come from aerated dilution water or from samples that are at a lower temperature than 20 degrees C. Since cold water will hold more dissolved air, aerating cold dilution water will give higher oxygen content than if the dilution water was aerated at 20 C. After placing the samples in an incubator at 20 C, the water will warm and not be able to hold as much DO. As a result, bubbles may form in the bottles. This can also happen with a low dilution sample, such as an effluent composite sample that was collected at 4 C and not warmed to temperature. It's important to always warm samples to 20 C, then shake the sample to remove excess dissolved oxygen before setting up for BOD. If your laboratory has heating problems, as they all seem to have, try storing the dilution water in your incubator overnight to stabilize the temperature to 20 C. This will help remove excess dissolved oxygen from the dilution water. (Tim Loftus, 2003)

Sometimes the sample may be toxic to the bacteria, or seed, that break down the wastes. This is often seen as decreasing BOD results on a sample coinciding with decreasing dilution rates. For example, three dilutions (1%, 2%, 3%) of an industrial wastewater sample gives results of 450 mg/L, 375 mg/L, and 250 mg/L respectively. This indicates a level of toxicity

in the sample. In these cases, calculate the BOD value using the most diluted sample (450 mg/L) since this shows the least effect of toxicity. (Tim Loftus, 2003)

For the percentage difference, refer to APPENDIX 12. When compared Aerobic Train 1 Effluent with Aerobic Train 2 Effluent, there is no significant different between both of them since t Stat < 2.3 and the H_0 is acceptable. Same goes when compared between Influent with Aerobic Train 2 Effluent, but the different between t Stat and t Critical two tails is not so much different. The comparison between Influent with Anaerobic Train 1 and comparison of Anaerobic Train 1 Effluent with Aerobic Train 1 Effluent also H_0 are acceptable since t Stat for both of them are less than t Critical two tails.

4.7 TSS Results

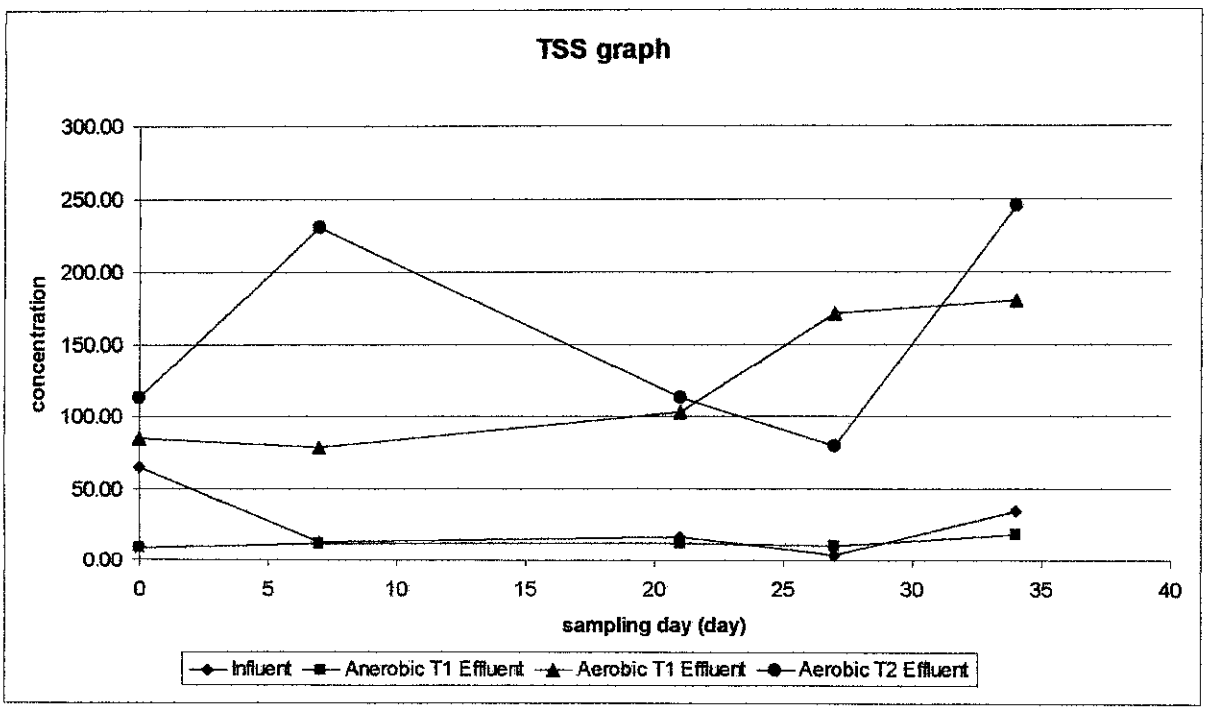

FIGURE 4.11: Graph of TSS vs Sampling day for both trains

For influent, the result is reasonable because TCOD and SCOD (FIGURE 4.1 AND 4.2) are not so much different. That is why the reading for TSS is low. Same goes to Anaerobic in Train 1, the TSS value is not higher because the different between TCOD and SCOD in not a big gap. For Aerobic Train 1 and Train 2, the result also satisfied. The main point is the value

of TSS should be lesser when there is no big gap between TCOD and SCOD. What can say is if there is a big gap between TCOD and SCOD, the TSS value also increased.

Not much solids wasted out from anaerobic reactors Train 1 but the effluent TSS from Train 1 were found to be higher. This indicates that biomass from the reactor maybe wash out into the effluent. This maybe caused of effluent TCOD from Train 1 to be higher. The effluent TSS from Train 2 was not stable throughout the sampling days.
Solids found in effluents may be classified as suspended, dissolved, colloidal or settleable. (The standard, TZS 574: 1997)

By referring to APPENDIX 13, the percentage difference for all comparison are H_o are acceptable since the t Stat is less than the t Critical two tails. So, there were no significant different between their comparison.

CHAPTER 5
CONCLUSION

As a conclusion, the sludge age was too long. Since the standard is about 20 days – 40 days (APPENDIX 6). For Train 1 the SRT is 73 days, while for Train 2 is 43 days. The sludge that was taken from the Sewage Treatment Plant was an aerobic bacterium. So, it might effected the anaerobic reactor since it is used the aerobic bacterium. It can be worked, but it needs more time to adapt with anaerobic condition.

As compare COD with BOD, the COD test has a major advantage over the BOD analysis because of the short time required for performance, a few hours as opposed to five days for the standard BOD test. Since this test can be run in several hours, it gives the operator a more timely idea of what is entering the plant and how the plant is performing. This permits closer operational control of the treatment process. Generally, COD values are higher than BOD values. The reason is that BOD measures only the quantity of organic material capable of being oxidized, while the COD represents a more complete oxidation.

By referring to Appendix 5, in Malaysia are used Standard A and B. For Standard A, BOD is 20 mg/L while COD is 50 mg/L. But for Standard B, the value for BOD is 50 mg/L, while the COD is 100 mg/L.

Besides that, care must be taken in the BOD5/CBOD5 test to make sure there are no sources of biodegradable organic material other than that present in the sample. To check for such contamination of samples, at least one "blank" is run with each batch of samples. The blank consists of "dilution water" which is reagent grade water containing nutrients and buffers. Ideally, blanks should not deplete any DO during the 5-day incubation, but a depletion of 0.2 mg/L is allowed by the method. Each batch of samples should also include

at least one "standard" which is a solution containing 150 mg/L each of glucose and glutamic acid.

For the TSS, the main point is the value of TSS should be lesser when there is no big gap between TCOD and SCOD. What can say is if there is a big gap between TCOD and SCOD, the TSS value also increased.

The bacteria that were existed in the reactor are filamentous, aspidisca and spirogyra. (FIGURE 4.11 and FIGURE 4.13)

For the F/M ratio for Train 1 is averagely 0.1 COD/MLVSS, and it is within the range which is 0.04 COD/MLVSS– 0.1 COD/MLVSS (Tchobanoglous G., Burton F. L.,Stensel H.D., 2004). But for the Train 2, it is 0.13 COD/MLVSS which is slightly higher than the range.

Lastly, the reactors were performing as a sludge digestion through aerobic wash away respiration at long sludge age and low F/M ratio.

REFERENCES

1. Beychok, M. (1967) Aqueous Wastes from Petroleum and Petrochemical Plants, First edition, John Wiley & Sons, LCCN 67019834
2. Clair N. Sawyer, Perry L. Mccarty, Gene F. Parkin (2003). Chemistry For Environmental Engineering And Science, 5th Edition, New York: Mcgraw-Hill. Isbn 0-07-248066-1.
3. Charles L. Woodruff 1999, Plant brochure revised in June 2004.
4. Corbitt, R. A. "Wastewater Disposal." In *Standard Handbook of Environmental Engineering*, edited by R. A. Corbitt. New York: McGraw-Hill, 1990.
5. Gaudy Jr., A. F., and E. T. Gaudy. *Microbiology for Environmental Scientists and Engineers*. New York: McGraw-Hill, 1980.
6. Ghosh, S., and D. Klass. 1977. Two-Phase Anaerobic Digestion, U.S. Patent No. 4,022,665
7. Jim A. Field et. Al (2002). "Role of organic acids in the Manganese-independent biobleaching system of *Bjerkandera* sp. Strain BOS55". *Applied and Environmental Microbiology*. 64 (7): 2409-2417
8. Lenore S. Clescerl, Arnold E. Greenberg, Andrew D. Eaton. Standard Methods For Examination Of Water & Wastewater, 20th Edition, Washington, Dc: American Public Health Association. Isbn 0-87553-235-7. Stevens Institute Of Technology
9. Lehr Et. Al. 2005, "Water Encyclopedia", Volume 1-5, Page 4336
10. Nusbaum, I. 1958. New Method for Determination of Suspended Solids. Sewage Ind. Wastes 30:1066.
11. Smith, A.L. & A.E. Greenberg. 1963. Evaluation of Methods For Determining Suspended Solids In Wastewater. J. Water Pollut. Control Fed. 35:940.
12. Trees, C.C. 1978. Analytical Analysis of the Effect Of Dissolved Solids On Suspended Solids Determination. J. Water Pollut. Control Fed. 50:2370.
13. Tim Loftus Et. Al, 2003 : Proposal for a Model State Watershed Management Act,. E*vironmental Law*, 34(4, December):929-947.
14. Tchobanoglous G., Burton F. L.,Stensel H.D. (2004), Wastewater Engineering, Treatment And Reuse, Fourth Edition, Mc Graw Hill, New York.
15. Tanzania Bureau of Standards, TBS, 1997 Finalized Tanzania Standards: Specification for Drinking Water-Part-1,: TZS 574. Dar es Salaam

16. Virginiaa Mid and Gregory D. Boardman. (1997). Hazardous wastes. Environmental Engineering Program, Department of Civil Engineering, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.656 pages. ISBN: 1566765927.
17. Banchetti R.; Erra F.; Ricci N.; Dini F. Volume 81, Number 1, January 2003 , pp. 14-20(7)
18. Ricci, N. 1996. Ethology of ciliates. *In* Ciliates: cells as organisms. *Edited by* K. Hausmann and P.C. Bradbury. Gustav Fischer Verlag, Stuttgart, Germany. pp. 403–416.
19. Andrew D. Eaton et Al, 2005: Standard Methods For The Examination of Water na Wastewater, 21st Edition.
20. Peter Wright, Sr., Scott Inglis , 2003, "Overview of Anaerobic Digestion Systems for Dairy Farms", An Economic Comparison of Two Anaerobic Digestion Systems on Dairy Farms Published by the American Society of Agricultural and Biological Engineers, St. Joseph, Michigan, paper number 034154.
21. P. Baltrėnas, E. Raistenskis, A. Zigmontienė, 2004 : Experimental Investigation Of Biogas Emissions During Organic Waste Biodegradation Processes
22. Karena Ostrem, 2004 : Greening Waste: Anaerobic Digestion For Treating The Organic Fraction Of Municipal Solid Wastes
23. Pollock, David C, 2006 : Methods for biological treatment of waste waters

APPENDICES

APPENDIX 1: COD RESULTS

Date	2/1/2008						13/02/2008					
Sample	Spektro Readings	Dilution Factor	TCOD (mg/L)	Spektro Readings	Dilution Factor	SCOD (mg/L)	Spektro Readings	Dilution Factor	TCOD (mg/L)	Spektro Readings	Dilution Factor	SCOD (mg/L)
Influent	73	1	76.50	65	1	65.50	128	1	92.50	89	1	88.00
	80	1		80	1		92	1		88	1	
	91	1		66	1		93	1		87	1	
Effluent Anaerobic Train 1	159	1	161.00	153	1	154.33	69	1	68.00	64	1	61.50
	165	1		158	1		67	1		59	1	
	159	1		152	1		82	1		73	1	
Effluent Aerobic Train 1	358	1	349.00	313	1	319.00	191	1	210.00	113	1	103.00
	340	1		319	1		210	1		100	1	
	322	1		319	1		210	1		106	1	
Effluent Aerobic Train 2	182	1	181.50	184	1	179.00	200	1	210.00	78	1	76.50
	161	1		227	1		220	1		91	1	
	181	1		174	1		217	1		75	1	

Date	21/02/2008						28/02/2008					
Sample	Spektro Readings	Dilution Factor	TCOD (mg/L)	Spektro Readings	Dilution Factor	SCOD (mg/L)	Spektro Readings	Dilution Factor	TCOD (mg/L)	Spektro Readings	Dilution Factor	SCOD (mg/L)
Influent	142	1	143.50	95	1	97.00	91	1	82.00	69	1	67.50
	181	1		112	1		84	1		76	1	
	145	1		99	1		80	1		66	1	
Effluent Anaerobic Train 1	50	1	54.00	51	1	48.00	60	1	73.50	53	1	57.00
	73	1		45	1		74	1		76	1	
	58	1		48	1		73	1		61	1	
Effluent Aerobic Train 1	247	1	254.00	226	1	240.50	202	1	232.00	167	1	167.00
	295	1		255	1		225	1		203	1	
	261	1		329	1		239	1		167	1	
Effluent Aerobic Train 2	252	1	233.00	74	1	67.50	190	1	210.50	89	1	90.00
	238	1		68	1		215	1		106	1	
	228	1		67	1		206	1		91	1	

Date	5/3/2008					
Sample	Spektro Readings	Dilution Factor	TCOD (mg/L)	Spektro Readings	Dilution Factor	SCOD (mg/L)
Influent	87	1	87.00	94	1	79.50
	79	1		85	1	
	95	1		74	1	
Effluent Anaerobic Train 1	62	1	67.70	54	1	65.50
	72	1		67	1	
	69	1		64	1	
Effluent Aerobic Train 1	208	1	234.50	153	1	160.67
	236	1		160	1	
	233	1		169	1	
Effluent Aerobic Train 2	234	1	207.50	63	1	85.00
	209	1		85	1	
	206	1		85	1	

13/03/08					
Spektro Readings	Dilution Factor	TCOD (mg/L)	Spektro Readings	Dilution Factor	SCOD (mg/L)
69	1	79.00	55	1	58.50
80	1		62	1	
110	1		77	1	
68	1	67.00	25	1	51.50
66	1		51	1	
95	1		52	1	
222	1	230.00	164	1	169.00
238	1		193	1	
266	1		174	1	
288	1	166.50	59	1	78.50
154	1		70	1	
179	1		87	1	

Date	19/3/2008					
Sample	Spektro Readings	Dilution Factor	TCOD (mg/L)	Spektro Readings	Dilution Factor	SCOD (mg/L)
Influent	45	1	53.33	51	1	51.67
	63	1		57	1	
	52	1		47	1	
Effluent Anaerobic Train 1	59	1	65.00	59	1	57.67
	71	1		55	1	
	92	1		59	1	
Effluent Aerobic Train 1	264	1	262.67	204	1	218.33
	261	1		233	1	
	263	1		218	1	
Effluent Aerobic Train 2	138	1	159.00	85	1	77.50
	151	1		109	1	
	167	1		70	1	

26/3/2008					
Spektro Readings	Dilution Factor	TCOD (mg/L)	Spektro Readings	Dilution Factor	SCOD (mg/L)
72	1	67.00	52	1	52.67
68	1		58	1	
61	1		48	1	
70	1	66.00	41	1	46.33
62	1		52	1	
58	1		46	1	
234	1	248.33	201	1	208.33
266	1		225	1	
245	1		199	1	
203	1	214.00	60	1	66.00
212	1		56	1	
216	1		72	1	

APPENDIX 2: BOD RESULTS

Date		21/02/2008						28/02/2008					
Sample	Sample Number	DO reading (mg/L)		Dilution Factor	DO different	BOD	Average BOD (mg/L)	DO reading (mg/L)		Dilution Factor	DO different	BOD	Average BOD (mg/L)
		Before	After					Before	After				
Influent	A1	10.40	5.47	1	4.93	47.60	51.00	9.51	5.56	1	3.95	37.80	33.75
	A2	10.62	5.36	1	5.26	50.90		9.46	5.90	1	3.56	33.90	
	A3	10.57	5.29	1	5.28	51.10		9.48	5.95	1	3.53	33.60	
Effluent Anaerobic Train 1	B1	10.51	7.01	1	3.50	33.30	23.65	9.65	7.69	1	1.96	17.90	16.05
	B2	10.41	7.95	1	2.46	22.90		9.55	7.96	1	1.59	14.20	
	B3	10.48	7.87	1	2.61	24.40		9.56	8.45	1	1.11	9.40	
Effluent Aerobic Train 1	C1	10.53	7.75	1	2.78	26.10	22.85	9.56	8.22	1	1.34	11.70	12.10
	C2	10.49	8.10	1	2.39	22.20		9.53	8.35	1	1.18	10.10	
	C3	10.54	8.02	1	2.52	23.50		9.52	8.10	1	1.42	12.50	
Effluent Aerobic Train 2	D1	10.33	7.30	1	3.03	28.60	28.33	9.50	8.43	1	1.07	9.00	8.80
	D2	10.41	7.50	1	2.91	27.40		9.46	8.41	1	1.05	8.80	
	D3	10.50	7.43	1	3.07	29.00		9.37	8.34	1	1.03	8.60	
Blank	1	10.41	10.26	1	0.15		0.17	9.39	9.20	1	0.19		0.18
	2	10.47	10.30	1	0.17			9.43	9.26	1	0.17		
	3	10.47	10.28	1	0.19			9.39	9.21	1	0.18		
Standard BOD	A	10.33	1.22	1	9.11		9.16	9.46	1.17	1	8.29		8.31
	B	10.43	1.16	1	9.27			9.45	1.15	1	8.30		
	C	10.25	1.15	1	9.10			9.5	1.17	1	8.33		

Date		13/03/2008						19/03/2008					
Sample	Sample Number	DO reading (mg/L)		Dilution Factor	DO different	BOD	Average BOD (mg/L)	DO reading (mg/L)		Dilution Factor	DO different	BOD	Average BOD (mg/L)
		Before	After					Before	After				
Influent	A1	9.33	7.14	1	2.19	20.20	19.60	8.96	7.02	1	1.94	17.70	17.90
	A2	9.30	7.23	1	2.07	19.00		9.04	7.06	1	1.98	18.10	
	A3	9.32	7.40	1	1.92	17.50		9.01	7.15	1	1.86	16.90	
Effluent Anaerobic Train 1	B1	9.24	7.96	1	1.28	11.10	10.87	8.98	7.52	1	1.46	12.90	12.65
	B2	9.22	8.02	1	1.20	10.30		8.94	7.10	1	1.84	16.70	
	B3	9.25	7.96	1	1.29	11.20		8.97	7.56	1	1.41	12.40	
Effluent Aerobic Train 1	C1	9.26	8.30	1	0.96	7.90	8.10	9.05	8.01	1	1.04	8.70	9.27
	C2	9.20	8.57	1	0.63	4.60		9.00	7.92	1	1.08	9.10	
	C3	9.20	8.20	1	1.00	8.30		9.02	7.85	1	1.17	10.00	
Effluent Aerobic Train 2	D1	9.28	8.42	1	0.86	6.90	6.93	9.06	8.20	1	0.86	6.90	6.63
	D2	9.26	8.42	1	0.84	6.70		8.95	8.14	1	0.81	6.40	
	D3	9.30	8.41	1	0.89	7.20		9.02	8.19	1	0.83	6.60	
Blank	1	9.41	9.23	1	0.18		0.18	8.96	8.75	1	0.21		0.19
	2	9.44	9.27	1	0.17			9.01	8.82	1	0.19		
	3	9.39	9.20	1	0.19			8.89	8.71	1	0.18		
Standard BOD	A			1						1			
	B			1						1			
	C			1						1			

Date		26/03/2008					
Sample	Sample Number	DO reading (mg/L)		Dilution Factor	DO different	BOD	Average BOD (mg/L)
		Before	After				
Influent	A1	8.79	6.87	1	1.92	17.50	17.40
	A2	8.61	6.71	1	1.90	17.30	
	A3	8.81	6.98	1	1.83	16.60	
Effluent Anaerobic Train 1	B1	8.15	6.85	1	1.30	11.30	11.65
	B2	8.11	6.79	1	1.32	11.50	
	B3	8.11	6.74	1	1.37	12.00	
Effluent Aerobic Train 1	C1	8.79	7.77	1	1.02	8.50	9.10
	C2	8.88	7.74	1	1.14	9.70	
	C3	8.09	7.01	1	1.08	9.10	
Effluent Aerobic Train 2	D1	8.23	7.40	1	0.83	6.60	7.27
	D2	8.29	7.30	1	0.99	8.20	
	D3	8.32	7.45	1	0.87	7.00	
Blank	1	8.60	8.40	1	0.20		0.19
	2	8.82	8.65	1	0.17		
	3	9.06	8.87	1	0.19		
Standard BOD	A			1			
	B			1			
	C			1			

APPENDIX 3: TSS RESULTS

21/02/2008							
Sample	Sample Number	Foil+Paper (after 105 C)	After filter	Sample Vol. (L)	Dilution Factor	TSS/MLSS (mg/L)	
Influent	A1	1.2982	1.3028	0.1	1	46	65
	A2	1.3324	1.3391	0.1	1	67	
	A3	1.3297	1.3360	0.1	1	63	
Effluent Anaerobic Train 1	B1	1.2739	1.2748	0.1	1	9	9
	B2	1.2848	1.2856	0.1	1	8	
	B3	1.3194	1.3188	0.1	1	-6	
Effluent Aerobic Train 1	C1	1.2968	1.3056	0.1	1	88	85
	C2	1.2837	1.2919	0.1	1	82	
	C3	1.3390	1.3474	0.1	1	84	
Effluent Aerobic Train 2	D1	1.3186	1.3302	0.1	1	116	113
	D2	1.3203	1.3313	0.1	1	110	
	D3	1.2795	1.2923	0.1	1	128	

28/02/2008							
Sample	Sample Number	Foil+Paper (after 105 C)	After filter	Sample Vol. (L)	Dilution Factor	TSS (mg/L)	
Influent	A1	1.3296	1.3310	0.1	1	14	13
	A2	1.3391	1.3402	0.1	1	11	
	A3	1.3294	1.3300	0.1	1	6	
Effluent Anaerobic Train 1	B1	1.2788	1.2804	0.1	1	16	12
	B2	1.2943	1.2955	0.1	1	12	
	B3	1.3272	1.3283	0.1	1	11	
Effluent Aerobic Train 1	C1	1.3117	1.3296	0.05	1	358	78
	C2	1.2858	1.2885	0.05	1	54	
	C3	1.3158	1.3209	0.05	1	102	
Effluent Aerobic Train 2	D1	1.3389	1.3462	0.05	1	146	231
	D2	1.3326	1.3454	0.05	1	256	
	D3	1.3118	1.3221	0.05	1	206	

13/03/2008							
Sample	Sample Number	Foil+Paper (after 105 C)	After filter	Sample Vol. (L)	Dilution Factor	TSS (mg/L)	
Influent	A1	1.2758	1.2768	0.1	1	10	16
	A2	1.3335	1.3352	0.1	1	17	
	A3	1.3257	1.3272	0.1	1	15	
Effluent Anaerobic Train 1	B1	1.2937	1.2955	0.1	1	18	12
	B2	1.2957	1.2967	0.1	1	10	
	B3	1.3386	1.3400	0.1	1	14	
Effluent Aerobic Train 1	C1	1.3466	1.3503	0.05	1	74	103
	C2	1.3077	1.3132	0.05	1	110	
	C3	1.2900	1.2948	0.05	1	96	
Effluent Aerobic Train 2	D1	1.2706	1.2763	0.05	1	114	113
	D2	1.2790	1.2846	0.05	1	112	
	D3	1.3239	1.3317	0.05	1	156	

19/03/2008							
Sample	Sample Number	Foil+Paper (after 105 C)	After filter	Sample Vol. (L)	Dilution Factor	TSS (mg/L)	
Influent	A1	1.3472	1.3476	0.1	1	4	4
	A2	1.3404	1.3409	0.1	1	5	
	A3	1.3321	1.3325	0.1	1	4	
Effluent Anaerobic Train 1	B1	1.2830	1.2840	0.1	1	10	10
	B2	1.3016	1.3024	0.1	1	8	
	B3	1.3324	1.3337	0.1	1	13	
Effluent Aerobic Train 1	C1	1.3302	1.3386	0.05	1	168	171
	C2	1.4120	1.4203	0.05	1	166	
	C3	1.3070	1.3159	0.05	1	178	
Effluent Aerobic Train 2	D1	1.3440	1.3478	0.05	1	76	79
	D2	1.2773	1.2815	0.05	1	84	
	D3	1.3378	1.3417	0.05	1	78	

26/03/2008							
Sample	Sample Number	Foil+Paper (after 105 C)	After filter	Sample Vol. (L)	Dilution Factor	TSS (mg/L)	
Influent	A1	1.3179	1.3220	0.1	1	41	34
	A2	1.2892	1.2924	0.1	1	32	
	A3	1.3341	1.3370	0.1	1	29	
Effluent Anaerobic Train 1	B1	1.2821	1.2839	0.1	1	18	18
	B2	1.3329	1.3348	0.1	1	19	
	B3	1.3065	1.3083	0.1	1	18	
Effluent Aerobic Train 1	C1	1.2810	1.2896	0.05	1	172	180
	C2	1.3431	1.3523	0.05	1	184	
	C3	1.2697	1.2789	0.05	1	184	
Effluent Aerobic Train 2	D1	1.2882	1.3000	0.05	1	236	245
	D2	1.3246	1.3371	0.05	1	250	
	D3	1.2766	1.2891	0.05	1	250	

APPENDIX 4: MLSS and MLVSS RESULTS

1/2/2008

Sample	Sample Number	Weight (g)				Sample Vol.	Dilution	MLSS (mg/L)		MLFSS (mg/L)		MLVSS (mg/L)		ratio mlvss/mlss
		Foil	Foil+Paper	Paper+Foil+TSS	Foil+Fix TSS	(L)	Factor							
MLSS & MLVSS Train 1	E1	1.1855	1.3399	1.3460	1.1876	0.1	100	6100		2100		4000		
	E2	1.1624	1.3149	1.3208	1.1642	0.1	100	5900	6000	1800	2000	4100	4000	0.667
	E3	1.1823	1.3410	1.3470	1.1844	0.1	100	6000		2100		3900		
MLSS & MLVSS Train 2	F1	1.1823	1.3386	1.3435	1.1839	0.1	100	4900		1600		3300		
	F2	1.1823	1.3341	1.3388	1.1841	0.1	100	4700	4767	1800	1600	2900	3167	0.664
	F3	1.1669	1.3240	1.3287	1.1683	0.1	100	4700		1400		3300		

13/02/2008

Sample	Sample Number	Weight (g)				Sample Vol.	Dilution	MLSS (mg/L)		MLFSS (mg/L)		MLVSS (mg/L)		ratio mlvss/mlss
		Foil	Foil+Paper	Paper+Foil+TSS	Foil+Fix TSS	(L)	Factor							
MLSS & MLVSS Train 1	E1	1.1855	1.3399	1.3449	1.1882	0.1	100	5000		2700		2300		
	E2	1.1624	1.3149	1.3201	1.1644	0.1	100	5200	5033	2000	2500	3200	2533	0.503
	E3	1.1823	1.3410	1.3459	1.1851	0.1	100	4900		2800		2100		
MLSS & MLVSS Train 2	F1	1.1823	1.3386	1.3413	1.1827	0.1	100	2700		400		2300		
	F2	1.1823	1.3341	1.3367	1.1828	0.1	100	2600	2733	500	567	2100	2167	0.793
	F3	1.1669	1.3240	1.3269	1.1677	0.1	100	2900		800		2100		

28/02/2008

Sample	Sample Number	Weight (g)				Sample Vol.	Dilution	MLSS (mg/L)		MLFSS (mg/L)		MLVSS (mg/L)		ratio mlvss/mlss
		Foil	Foil+Paper	Paper+Foil+TSS	Foil+Fix TSS	(L)	Factor							
MLSS & MLVSS Train 1	E1	1.1875	1.3389	1.3433	1.1894	0.1	100	4400		1900		2500		
	E2	1.1816	1.3320	1.3365	1.1830	0.1	100	4500	4367	1400	1800	3100	2500	0.573
	E3	1.1859	1.3331	1.3373	1.1876	0.1	100	4200		1700		2500		
MLSS & MLVSS Train 2	F1	1.1636	1.3101	1.3175	1.1646	0.1	100	7400		1000		6400		
	F2	1.1673	1.3195	1.3216	1.1684	0.1	100	2100	2600	1100	1100	1000	1500	0.577
	F3	1.1236	1.2779	1.2810	1.1247	0.1	100	3100		1100		2000		

13/3/2008

Sample	Sample Number	Weight (g)				Sample Vol.	Dilution	MLSS (mg/L)		MLFSS (mg/L)		MLVSS (mg/L)		ratio mlvss/mlss
		Foil	Foil+Paper	Paper+Foil+TSS	Foil+Fix TSS	(L)	Factor							
MLSS & MLVSS Train 1	E1	1.1760	1.3264	1.3310	1.1780	0.1	100	4600		2000		2600		0.523
	E2	1.1640	1.3150	1.3189	1.1660	0.1	100	3900	4333	2000	2067	1900	2267	
	E3	1.1837	1.3325	1.3370	1.1859	0.1	100	4500		2200		2300		
MLSS & MLVSS Train 2	F1	1.1812	1.3223	1.3253	1.1830	0.1	100	3000		1800		1200		0.435
	F2	1.1259	1.2757	1.2784	1.1275	0.1	100	2700	2833	1600	466.67	1100	1233	
	F3	1.1243	1.2748	1.2776	1.1257	0.1	100	2800		1400		1400		

19/3/2008

Sample	Sample Number	Weight (g)				Sample Vol.	Dilution	MLSS (mg/L)		MLFSS (mg/L)		MLVSS (mg/L)		ratio mlvss/mlss
		Foil	Foil+Paper	Paper+Foil+TSS	Foil+Fix TSS	(L)	Factor							
MLSS & MLVSS Train 1	E1	1.1286	1.2742	1.2774	1.1294	0.1	100	3200		800		2400		0.742
	E2	1.1750	1.3266	1.3300	1.1759	0.1	100	3400	3300	900	850	2500	2450	
	E3	1.1954	1.3448	1.3492	1.1966	0.1	100	4400		1200		3200		
MLSS & MLVSS Train 2	F1	1.1645	1.3050	1.3124	1.1655	0.1	100	7400		1000		6400		0.500
	F2	1.1791	1.3268	1.3292	1.1803	0.1	100	2400	2500	1200	1167	1200	1250	
	F3	1.1839	1.3286	1.3312	1.1852	0.1	100	2600		1300		1300		

26/3/2008

Sample	Sample Number	Weight (g)				Sample Vol.	Dilution	MLSS (mg/L)		MLFSS (mg/L)		MLVSS (mg/L)		ratio mlvss/mlss
		Foil	Foil+Paper	Paper+Foil+TSS	Foil+Fix TSS	(L)	Factor							
MLSS & MLVSS Train 1	E1	1.1695	1.2816	1.2861	1.1710	0.1	100	4500		1500		3000		0.645
	E2	1.1733	1.2709	1.2751	1.1747	0.1	100	4200	4600	1400	1500	2800	2967	
	E3	1.1131	1.3104	1.3151	1.1147	0.1	100	4700		1600		3100		
MLSS & MLVSS Train 2	F1	1.1330	1.3157	1.3196	1.1345	0.1	100	3900		1500		2400		0.500
	F2	1.1202	1.3255	1.3292	1.1221	0.1	100	3700	3900	1900	1950	1800	1950	
	F3	1.1624	1.2629	1.2670	1.1644	0.1	100	4100		2000		2100		

3/4/2008														
Sample	Sample Number	Weight (g)				Sample Vol.	Dilution	MLSS (mg/L)		MLFSS (mg/L)		MLVSS (mg/L)		ratio mlvss/mlss
		Foil	Foil+Paper	Paper+Foil+TSS	Foil+Fix TSS	(L)	Factor							
MLSS & MLVSS Train 1	E1	1.1827	1.3257	1.3295	1.1845	0.1	100	3800		1820		1980		
	E2	1.1675	1.3126	1.3172	1.1696	0.1	100	4600	4550	2100	2000	2500	2550	0.560
	E3	1.1700	1.3117	1.3162	1.1719	0.1	100	4500		1900		2600		
MLSS & MLVSS Train 2	F1	1.1854	1.3303	1.3343	1.1874	0.1	100	4000		2000		2000		
	F2	1.1197	1.2686	1.2723	1.1215	0.1	100	3700	3833	1800	1933	1900	1900	0.496
	F3	1.1381	1.2826	1.2864	1.1401	0.1	100	3800		2000		1800		

APPENDIX 5: PARAMETER LIMITS OF EFFLUENT OF STANDARDS A AND B

Parameter	Unit	Standard	
		A	B
Temperature	C	40	40
pH Value		6.0 - 9.0	5.5 - 9.0
BODs at 20°C	mg/L	20	50
COD	mg/L	50	100
Suspended Solids	mg/L	50	100
Mercury	mg/L	0.005	0.005
Cadmium	mg/L	0.01	0.02
Chromium,Hexavaient	mg/L	0.05	0.05
Arsenic	mg/L	0.05	0.10
Cyanide	mg/L	0.05	0.10
Lead	mg/L	0.10	0.5
Chromium, Trivalent	mg/L	0.20	1.0
Copper	mg/L	0.20	1.0
Manganese	mg/L	0.20	1.0
Nickel	mg/L	0.20	1.0
Tin	mg/L	0.20	1.0
Zinc	mg/L	1.0	1.0
Borom	mg/L	1.0	4.0
Iron (Fe)	mg/L	1.0	5.0
Phenol	mg/L	0.001	1.0
Free Chlorine	mg/L	1.0	2.0
Sulphide	mg/L	0.50	0.50
Oil and Grease	mg/L	Not Detectable	10.0

APPENDIX 6: HRT AND SRT

Hydraulic Detention Time (HRT) = $\frac{\text{volume of reactor , V}}{\text{Flowrate, Q}}$

$= \frac{18L}{3L/day}$

$= 6 \text{ days}$

Solids Retention Time (SRT)

Weight of biomass in reactor (mg), A = V x MLVSS (mg/L)

Wasted sludge (mg per day), B = Q x TSS (mg/L)

Biomass in effluent (mg per day), C = v x MLVSS (mg/L)

Where:

V = volume of the reactor (L)

Q = flow rate (L/day)

v = volume of wasted sludge (L)

$$SRT\,(days) = \frac{A}{(B + C)}$$

Sludge Aerobic Train 1

Average MLVSS = 2545 mg/L

Average TSS = 123.40 mg/L

V = 18L

Q = 3 L/day

v = 0.1L

$$SRT = \frac{18x2545}{((3x123.4) + (0.1x2545))}$$

$SRT = 73$ days

Sludge Aerobic Train 2

Average MLVSS = 1667 mg/L

Average TSS = 175.50 mg/L

V = 18L

Q = 3 L/day

v = 0.1L

$$SRT = \frac{18x1667}{((3x175.5) + (0.1x1667))}$$

$SRT = 43$ days

APPENDIX 7: PERCENTAGE DIFFERENCE FOR TCOD

Aerobic Train 1 Effluent compared to Aerobic Train 2 Effluent

t-Test: Two-Sample Assuming Equal Variances

	Aerobic T1 Effluent	*Aerobic T2 Effluent*
Mean	252.5625	197.75
Variance	1784.57665	665.2142857
Observations	8	8
Pooled Variance	1224.895468	
Hypothesized Mean Difference	0	
df	14	
t Stat	3.132276502	
P(T<=t) one-tail	0.003672948	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	0.007345896	
t Critical two-tail	2.144786681	

Since t stat > 2.14, hence reject Ho, there is significant different between TCOD for aerobic T1 Effluent and Aerobic T2 effluent

Influent compared to Aerobic Train 2 Effluent

t-Test: Two-Sample Assuming Equal Variances

	Inlfuent	*Aerobic T2 Effluent*
Mean	85.10375	197.75
Variance	703.8075411	665.2142857
Observations	8	8
Pooled Variance	684.5109134	
Hypothesized Mean Difference	0	
df	14	
t Stat	-8.611058625	
P(T<=t) one-tail	2.87728E-07	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	5.75456E-07	
t Critical two-tail	2.144786681	

Since t stat < - 2.14, hence reject Ho, there is significant different between TCOD for Influent and Aerobic T2 effluent

Influent compared to Anaerobic Train 1 Effluent

t-Test: Two-Sample Assuming Equal Variances

	Inlfuent	*Anerobic T1 Effluent*
Mean	85.10375	77.775
Variance	703.8075411	1160.705
Observations	8	8
Pooled Variance	932.2562705	
Hypothesized Mean Difference	0	
df	14	
t Stat	0.48005638	
P(T<=t) one-tail	0.319300604	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	0.638601208	
t Critical two-tail	2.144786681	

Since -2.14 < t stat < 2.14, hence accept Ho, there is no significant different between TCOD for Influent and Aerobic T1 effluent

Anaerobic T1 Effluent compared to Aerobic Train 1 Effluent

t-Test: Two-Sample Assuming Equal Variances

	Anerobic T1 Effluent	*Aerobic T1 Effluent*
Mean	77.775	252.5625
Variance	1160.705	1784.57665
Observations	8	8
Pooled Variance	1472.640825	
Hypothesized Mean Difference	0	
df	14	
t Stat	-9.109445635	
P(T<=t) one-tail	1.46396E-07	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	2.92793E-07	
t Critical two-tail	2.144786681	

Since t stat < -2.14, hence reject Ho, there is significant different between TCOD for Anaerobic T1 Effluent and Aerobic T1 effluent.

APPENDIX 8: PERCENTAGE DIFFERENCE FOR SCOD

Aerobic Train 1 Effluent compared to Aerobic Train 2 Effluent

t-Test: Two-Sample Assuming Equal Variances

	Aerobic T1 Effluent	*Aerobic T2 Effluent*
Mean	198.22875	90
Variance	4169.625441	1357
Observations	8	8
Pooled Variance	2763.312721	
Hypothesized Mean Difference	0	
df	14	
t Stat	4.117727664	
P(T<=t) one-tail	0.000522662	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	0.001045323	
t Critical two-tail	2.144786681	

Since t stat > 2.14, hence reject Ho, there is significant different between SCOD for Aerobic T1 Effluent and Aerobic T2 effluent.

Influent compared to Aerobic Train 2 Effluent

t-Test: Two-Sample Assuming Equal Variances

	Influent	*Aerobic T2 Effluent*
Mean	70.0425	90
Variance	276.9004786	1357
Observations	8	8
Pooled Variance	816.9502393	
Hypothesized Mean Difference	0	
df	14	
t Stat	-1.396491612	
P(T<=t) one-tail	0.092157095	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	0.18431419	
t Critical two-tail	2.144786681	

Since -2.14 < t stat < 2.14, hence accept Ho, there is no significant different between SCOD for Anaerobic T1 Effluent and Aerobic T1 effluent.

Influent compared to Anaerobic Train 1 Effluent

t-Test: Two-Sample Assuming Equal Variances

	Influent	*Anerobic T1 Effluent*
Mean	70.0425	67.72875
Variance	276.9004786	1267.189727
Observations	8	8
Pooled Variance	772.0451027	
Hypothesized Mean Difference	0	
df	14	
t Stat	0.166542504	
P(T<=t) one-tail	0.435055713	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	0.870111427	
t Critical two-tail	2.144786681	

Since t stat < 2.14, hence accept Ho, there is no significant different between SCOD for Influent and Anaerobic T1 effluent.

Anaerobic T1 Effluent compared to Aerobic Train 1 Effluent

t-Test: Two-Sample Assuming Equal Variances

	Anerobic T1 Effluent	*Aerobic T1 Effluent*
Mean	67.72875	198.22875
Variance	1267.189727	4169.625441
Observations	8	8
Pooled Variance	2718.407584	
Hypothesized Mean Difference	0	
df	14	
t Stat	-5.005912115	
P(T<=t) one-tail	9.61974E-05	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	0.000192395	
t Critical two-tail	2.144786681	

Since t stat < -2.14, hence reject Ho, there is significant different between SCOD for Anaerobic T1 Effluent and Aerobic T1 effluent.

APPENDIX 9: PERCENTAGE DIFFERENCE FOR BOD

Aerobic Train 1 Effluent compared to Aerobic Train 2 Effluent

t-Test: Two-Sample Assuming Equal Variances

	Aerobic T1 Effluent	*Aerobic T2 Effluent*
Mean	12.284	11.592
Variance	37.10053	88.24782
Observations	5	5
Pooled Variance	62.674175	
Hypothesized Mean Difference	0	
df	8	
t Stat	0.138207556	
P(T<=t) one-tail	0.446745934	
t Critical one-tail	1.859548033	
P(T<=t) two-tail	0.893491869	
t Critical two-tail	2.306004133	

Since t stat < 2.31, hence accept Ho, there is no significant different between SCOD for Aerobic T1 Effluent and Aerobic T2 effluent.

Influent compared to Aerobic Train 2 Effluent

t-Test: Two-Sample Assuming Equal Variances

	Influent	*Aerobic T2 Effluent*
Mean	27.93	11.592
Variance	211.742	88.24782
Observations	5	5
Pooled Variance	149.99491	
Hypothesized Mean Difference	0	
df	8	
t Stat	2.109262518	
P(T<=t) one-tail	0.033975618	
t Critical one-tail	1.859548033	
P(T<=t) two-tail	0.067951237	
t Critical two-tail	2.306004133	

Since t stat < 2.31, hence accept Ho, there is no significant different between SCOD for Influent and Aerobic T2 effluent.

Influent compared to Anaerobic Train 1 Effluent

t-Test: Two-Sample Assuming Equal Variances

	Influent	*Anaerobic T1 Effluent*
Mean	27.93	14.974
Variance	211.742	27.43088
Observations	5	5
Pooled Variance	119.58644	
Hypothesized Mean Difference	0	
df	8	
t Stat	1.873268261	
P(T<=t) one-tail	0.048956927	
t Critical one-tail	1.859548033	
P(T<=t) two-tail	0.097913853	
t Critical two-tail	2.306004133	

Since t stat < 2.31, hence accpet Ho, there is no significant different between SCOD for Influent and Anaerobic T1 effluent.

Anaerobic T1 Effluent compared to Aerobic Train 1 Effluent

t-Test: Two-Sample Assuming Equal Variances

	Anaerobic T1 Effluent	*Aerobic T1 Effluent*
Mean	14.974	12.284
Variance	27.43088	37.10053
Observations	5	5
Pooled Variance	32.265705	
Hypothesized Mean Difference	0	
df	8	
t Stat	0.748775636	
P(T<=t) one-tail	0.237714488	
t Critical one-tail	1.859548033	
P(T<=t) two-tail	0.475428976	
t Critical two-tail	2.306004133	

Since t stat < 2.31, hence accept Ho, there is no significant different between SCOD for Anaerobic T1 Effluent and Aerobic T1 effluent.

APPENDIX 10: PERCENTAGE DIFFERENCE FOR TSS

Aerobic Train 1 Effluent compared to Aerobic Train 2 Effluent

t-Test: Two-Sample Assuming Equal Variances

	Aerobic T1 Effluent	*Aerobic T2 Effluent*
Mean	123.4	156.2
Variance	2355.3	5793.2
Observations	5	5
Pooled Variance	4074.25	
Hypothesized Mean Difference	0	
df	8	
t Stat	-0.812493716	
P(T<=t) one-tail	0.220007371	
t Critical one-tail	1.859548033	
P(T<=t) two-tail	0.440014742	
t Critical two-tail	2.306004133	

Since -2.31 < t stat < 2.31, hence accept Ho, there is no significant different between TSS for Aerobic T1 Effluent and Aerobic T2 effluent.

Influent compared to Aerobic Train 2 Effluent

t-Test: Two-Sample Assuming Equal Variances

	Influent	*Aerobic T2 Effluent*
Mean	26.4	156.2
Variance	584.3	5793.2
Observations	5	5
Pooled Variance	3188.75	
Hypothesized Mean Difference	0	
df	8	
t Stat	-3.634414538	
P(T<=t) one-tail	0.00332122	
t Critical one-tail	1.859548033	
P(T<=t) two-tail	0.00664244	
t Critical two-tail	2.306004133	

Since t stat < -2.31, hence reject Ho, there is significant different between TSS for Influent and Aerobic T2 effluent.

Influent compared to Anaerobic Train 1 Effluent

t-Test: Two-Sample Assuming Equal Variances

	Influent	*Anerobic T1 Effluent*
Mean	26.4	12.2
Variance	584.3	12.2
Observations	5	5
Pooled Variance	298.25	
Hypothesized Mean Difference	0	
df	8	
t Stat	1.300074148	
P(T<=t) one-tail	0.114889709	
t Critical one-tail	1.859548033	
P(T<=t) two-tail	0.229779418	
t Critical two-tail	2.306004133	

Since t stat < 2.14, hence accept Ho, there is no significant different between TSS for Influent and Anaerobic T1 effluent.

Anaerobic T1 Effluent compared to Aerobic Train 1 Effluent

t-Test: Two-Sample Assuming Equal Variances

	Anerobic T1 Effluent	*Aerobic T1 Effluent*
Mean	12.2	123.4
Variance	12.2	2355.3
Observations	5	5
Pooled Variance	1183.75	
Hypothesized Mean Difference	0	
df	8	
t Stat	-5.110281167	
P(T<=t) one-tail	0.000459063	
t Critical one-tail	1.859548033	
P(T<=t) two-tail	0.000918125	
t Critical two-tail	2.306004133	

Since t stat < -2.14, hence reject Ho, there is significant different between TCOD for Anaerobic T1 Effluent and Aerobic T1 effluent.