CERTIFICATION OF APPROVAL

EVALUATING THE PERFORMANCE OF UNIVERSITI TEKNOLOGI PETRONAS (UTP) SEWAGE TREATMENT PLANT (STP) AND IMPACT OF CHEMICAL WASTE DISCHARGE ON TOTAL SUSPENDED SOLIDS REMOVAL IN CO-TREATING WITH UTP's WASTESTREAM

by

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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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(ZUL HELMY BIN ABDULLAH SUHAIMI)

ABSTRACT

This project is about to evaluate the performance of Universiti Teknologi Petronas Sewage Treatment Plant (UTP's STP) with the help of activated sludge wastewater treatment pilot plant. The sewage treatment plant (UTP's STP) consists of inlet chamber, grit and grease chamber, distribution chamber, anoxic zone, aeration tank, clarifier and chlorination tank; and the activated sludge wastewater treatment pilot plant consist of feeder tank, aeration tank and a clarifier. The main purpose of this project is to evaluate the performance of the secondary treatment process from UTP's STP consisting of an anoxic zone, aeration tank and a clarifier and evaluate the impact of chemical waste solution prior to treatment into the STP. A pilot plant with feeder tank, aeration tank and clarifier was used to stimulate the UTP's STP treatment process. The parameters that have been studied for this project is mixed liquor suspended solids (MLSS) or activated sludge, Total Suspended Solids (TSS) and Sludge Volume Index (SVI) or sludge settleability. Wastewater from UTP's STP was fed into the activated sludge wastewater treatment pilot plant once in a week. The flowrate and retention time measured from exact operation of UTP's STP was scaled down (1:6) in the pilot plant to stimulate the process of UTP's STP into the activated sludge wastewater treatment pilot plant. The laboratory experiment was done in two different phases. For Sewage Treatment Plant, in the first phase, tests were conducted before the oxidation pond wastewater was diverted to Sewage Treatment Plant and in the second phase, tests were conducted after the oxidation pond wastewater was diverted to Sewage Treatment Plant. Result obtained showed, the effluent from STP for both phases was met the Environmental Quality Act (EQA), 1974 standard. Meanwhile, for pilot plant, in the first phase, tests were conducted under the condition of no sludge recycle in activated sludge and in the second phase, tests were conducted under the condition of allowing sludge recycle in activated sludge addition with chemical waste solution discharge from Chemical Block 3 and 4. Result obtained showed, percentage of TSS removal in the first phase was 91% and dropped to 36% in the second phase. These suggested that additional of chemical waste gave an effect on the treatment plant operation. SVI results obtained showed, the settling quality of the pilot plant aerated mixed liquor was satisfied.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Wastewater collected from municipalities and communities must ultimately be returned to receiving waters or to the land. The complex question of which contaminants in wastewater must be removed to protect the environment and to what extend must be answered specifically for each case.

Nowadays, there are various methods to treat the municipal wastewater such as oxidation pond, aerated lagoon, activated sludge and etc. University Teknologi Petronas were using combination of mechanical equipment like primary screen, pump station, grit and grease chamber, distribution chamber, anoxic zone, aeration tank, clarifier and chlorination tank to make up UTP Sewage Treatment Plant. It is located in front of Lembaran Café and near to the Maintenance Building. The sewage treatment plant is used an Extended Aeration Activated Sludge (EEAS) and capable of processing BOD_5 to a standard better than 20mg/l BOD_5 and 50mg/l suspended solids (effluent quality of standard A). The aim of the treatment is to treat all the municipal wastewater before it is discharge to the main drain with respect to the regulation stated in the Environmental Quality Act (EQA), 1974. A hydraulic loading off 225 l/pe/d and an organic loading off 55 g/pe/d and sludge storage of 40 days at 4% of solid are considered for design. The design basis for flow rate on this plant is about 5,175.00 m^3/d or 23,000 population equivalent.

Loyal Wastewater Engineering Sdn. Bhd, is the contractor who is responsible for operating and maintaining the sewage treatment plant and Spectrum Laboratories (Penang) Sdn. Bhd was employs by Loyal Wastewater Engineering Sdn. Bhd to analyze the quality of effluent discharge from the sewage treatment plant. Three parameters were checked for the effluent discharge samples which are pH, BOD and TSS.

1.2 Problem Statement

The purpose of this project is to evaluate the performance of the UTP's STP in treating the UTP municipal wastewater by simulating the UTP's STP process into activated sludge wastewater treatment pilot plant which consists of feeder tank, aeration tank and a clarifier.

1.3 Objectives and Scope of Study

The main objectives of the project are:

i. To evaluate the performance of aeration and clarifier tank of UTP's STP by evaluating the operation system and analyzing / comparing results obtained from the laboratory tests.
ii. To determine pilot plant Total Suspended Solids (TSS) removal effect without recycle in activated sludge
iii. To determine pilot plant Total Suspended Solids (TSS) removal effect on co-treating segregated chemical waste with municipal wastewater.
iv. To determine pilot plant Total Suspended Solids (TSS) removal effect on reuse sludge from decommissioned oxidation pond as a feed for MLSS for UTP's STP.

The scopes of the study are:

i. Tests on influent/effluent parameters by Total Suspended Solids (TSS) test and Sludge Volume Index (SVI) test
ii. To use a simulated activated sludge treatment pilot plant system in enhancing the treatment performance of the UTP's STP.

CHAPTER 2

LITERATURE REVIEW AND THEORY

2.1 UTP Sewage Treatment Plant

University Technology Petronas Sewage Treatment Plant (UTP's STP) was built to treat all municipal wastewater from the villages in UTP and ensures the final discharge from this plant will comply with the regulation given by the Environmental Quality Act (EQA) 1974, before it is discharge into the main drain. Below are the Standard A and Standard B of EQA, 1974.

PARAMETER	UNITS	STANDARD	
		A	B
1. BOD_5 at 20°C	mg/l	20	50
2. Suspended solids	mg/l	50	100

Table2-1: Standard A and Standard B of EQA, 1974

Standard A is defined as the effluents which are released or discharge into the river from upstream of existing water intake point and Standard B is defined as the effluents which are released or discharge to non-catchments area. Since the final discharge for this oxidation pond is released to main drain and then to the river, thus this project is concern with the parameter given in Standard A [STP training course by Pakar Management Technology (PMT) Sdn Bhd].

This treatment plant is used an extended aeration activated sludge system that consist of two aeration tanks in parallel with two clarifier tanks, grit chamber, oil and grease chamber, distribution chamber, chlorination tank, gravity thicker and sludge holding tank. The sewage treatment plant is capable of processing BOD_5 to a standard better than 20mg/l BOD_5 and 50mg/l suspended solids (effluent quality of standard A). A hydraulic loading off 225 l/pe/d and an organic loading off 55 g/pe/d and sludge storage of 40 days at 4% of solid are condered for design. The design basis for flow rate on this plant is about

5,175.00 m^3/d or 23,000 population equivalent [STP training course by PMT (M) Sdn. Bhd.]. The figure below show the flow diagram of UTP Sewage Treatment Plant:

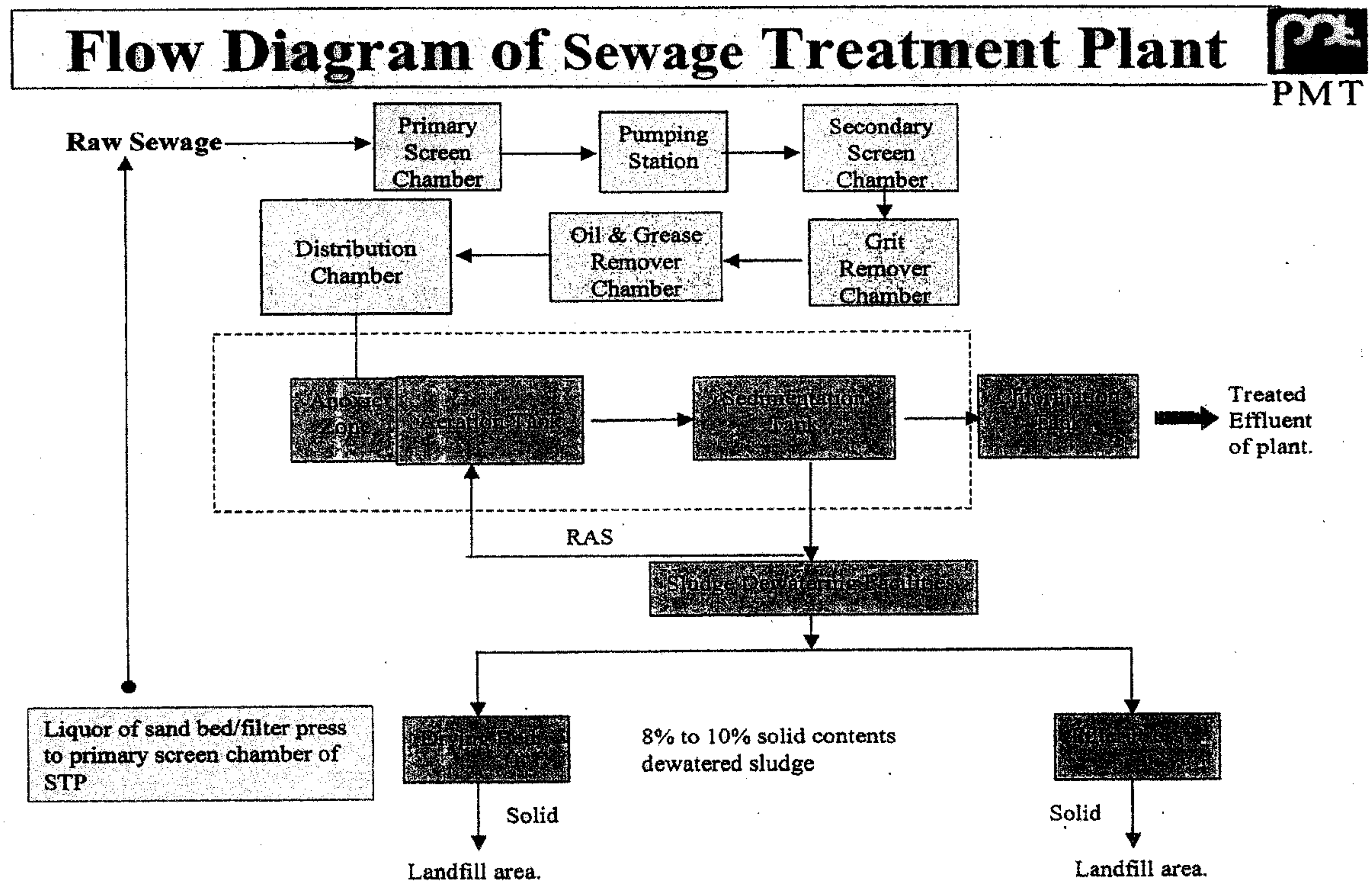


Figure 2-1: Flow Diagram of Sewage Treatment Plant

The first unit operation encountered in UTP's STP is a primary screen. All influent from municipal wastewater will be entering here and been channeled by gravity to the sump where stainless steel screen is installed at the bottom of this unit. The stainless steel screen consist of series of uniform openings (15 mm spacing) that is used to retain solids found in the influent wastewater to the treatment plant and to protect pumps, valves, pipelines and other appurtenances from damage or clogging by rags and large objects. There are two types of screen in this treatment plant which are mechanical and manual screen. Mechanical screen will be installed in parallel with a manual screen. The manual screen will serve as a backup during the failure of the mechanized system [STP training course by PMT (M) Sdn. Bhd.]. The principal role of screening is to remove course materials from the flow stream that could (1) damage subsequent process equipment, (2) reduce overall treatment process reliability and effectiveness, or (3) contaminate waterways [Metcalf & Eddy].

After the screen, the sewage flow into the sump and will be pumped up into the secondary screen chamber via 6 units of submersible pump. Four units of pump will be running during peak hour while the other unit serves as standby. The wastewater then will flow through the secondary stainless steel screen of 15 mm spacing where greater removal removals of solids are required to (1) protect process equipment or (2) eliminate materials that may inhibit the beneficial reuse of biosolids. Thus, it will reduce the remaining floating matters and finer particles from entering the aeration tank [STP training course by PMT (M) Sdn. Bhd.].

Horizontal chamber with 10 minutes detention time will be provided to remove oil and grease. Oil and grease are quite similar chemically; they are compounds (esters) of alchohol or glycerol (glycerin) with fatty acids. The glycerides of fatty acids that are liquid at ordinary temperatures are called oils, and those that are solids are called grease (or fats). If grease is not removed before discharge of treated wastewater, it can interfere with the biological life in the surface water and create unsightly films [Metcalf & Eddy]. The chamber will be equipped with oil grease channel along the side of the chamber. This channel is used for removal of oil and grease draw of to the oil grease collection skip [STP training course by PMT (M) Sdn. Bhd.].

From the grease trap, the wastewater goes to the anoxic zone. It is required by guideline for the treatment plant greater than 10,000 PE to have an anoxic zone. In this zone the effluent from aeration tank will be allow to mixed without additional dissolved oxygen. Anoxic denitrification process will occur which nitrate nitrogen is converted biologically to nitrogen gas in the absence of oxygen. This process is also known as anaerobic denitrification [STP training course by PMT (M) Sdn. Bhd.]. Nitrogen appears in organic wastes in various forms. In wastewater, four types of nitrogen are common: organic nitrogen, ammonia nitrogen, nitrite nitrogen, and nitrate nitrogen. These different forms constitute the total nitrogen content. The predominant forms of nitrogen in wastewater are organic nitrogen and ammonia (NH_3). Organic nitrogen is converted to ammonia in the first step of the nitrogen cycle [Metcalf & Eddy].

In order to remove nitrogen from wastewater, the ammonia must be oxidized to nitrate (NO_3). This process is commonly referred to as nitrification. An oxic environment must be maintained for a sufficient period of time to promote nitrification. In UTP's STP the oxic conditions are maintained by aerators. In the presence of dissolved oxygen, the microorganisms convert stored BOD (biochemical oxygen demand) to CO_2, water, and increased cell mass. Biological nitrification occurs, producing nitrite in an intermediate step and ultimately producing nitrate. Following nitrification, nitrogen can be removed from the wastewater by reducing the nitrate to nitrogen gas (N_2), which is released to the atmosphere. This process is commonly referred to as denitrification. Denitrification requires anoxic conditions, as well as an organic carbon source, to proceed [P.S. Barker, P.L. Dold].

Introducing an anoxic zone into the flow scheme provides for denitrification of nitrate. In this zone, operated with no dissolved oxygen (DO), the endogenous oxygen demand of mixed liquor suspended solids (MLSS) plus the carryover of BOD (biochemical oxygen demand) from the anaerobic zone causes denitrification of the nitrate produced in the aerobic zone [P.S. Barker, P.L. Dold].

During anoxic conditions, dissolved oxygen is not available to the microorganisms for respiration. Because of this, the oxygen molecules are stripped from the nitrate, causing the production of nitrogen gas (N_2). Carbon dioxide and water are also produced in the process, which results from the degradation of BOD. In addition, a portion of the alkalinity consumed during the nitrification process is restored through the denitrification process. When the mixed liquor flows to the secondary anoxic zones, there will be a relatively small concentration of extra cellular BOD in the wastewater. However, denitrification will still proceed since the microorganisms utilize internal storage products to reduce nitrate (endogenous denitrification) [Regina Williams].

The raw sewage will be treated in the aeration tank with forced aeration means of surface aerator. Air diffusion systems (fine and coarse) are used to deliver process air to and around the aeration tanks which is used to supply oxygen to the microorganisms and provide mixing of the suspended solids within each aeration tank. Process air is also delivered to the influent and effluent channels of the aeration basin and the influent channel to the final clarifiers. This process air, known as channel air, provides coarse bubble diffusion for two primary reasons: agitation, keeping the solids in suspension and the addition of air helps maintain a higher level of DO keeping the sewage fresh minimizing obnoxious odors [Regina Williams].

During normal operation two flow streams enter the aeration system, primary effluent (secondary influent wastewater) and Return Sludge (RSL) from the final clarifiers, called return activated sludge. When the RSL and the wastewater are mix together, the combination is known as mix liquor and often referred to as mix liquor suspended solids (MLSS). The mixed liquor volatile suspended solids (MLVSS) are an approximation of the viable microorganism in the system, which do the actual wastewater purification. Most organisms in activated sludge are obligate aerobes; they need free oxygen to stay alive. The fine bubble diffusers located on the bottom of the aeration basins provide the oxygen. The mixed liquor volatile suspended solids (MLVSS) to be maintained in the tank is about 4000 mg/l and expected BOD to be remove is over 90% in this treatment plant [STP training course by PMT (M) Sdn. Bhd.].

From the aeration tank, the wastewater will then overflow into the clarifier tank for the settlement of the sludge. The clear effluent will flow to the chlorination tank before it is discharged to the municipal drain. Active sludge from the clarifier is recycling at 60% back to the aeration tank [STP training course by PMT (M) Sdn. Bhd.].

Some sludge has to be wasted and disposed off periodically in order to minimize the operational cost. It is recommended by IWK/JPP to thicken the sludge in a sludge thickener in aerobic digestor. This sludge will be pump to the filter press periodically [STP training course by PMT (M) Sdn. Bhd.].

Filter press is provided for sludge dewatering. In filter press, dewatering will be achieved by forcing the water from the sludge under the high pressure. The filtrate water will be return back to the sump and sludge cake will be disposed of on landfill [STP training course by PMT (M) Sdn. Bhd.].

Loyal Wastewater Engineering Sdn. Bhd is hired as a contactor to operate this UTP Sewage Treatment Plan while Spectrum Laboratories (Penang) Sdn. Bhd is the company that is responsible for analyzing the quality of effluent discharge from the sewage treatment plant. Table 1 below showed the equipment of sewage treatment plant while table 2 showed the unit process description at the sewage treatment plant.

The day-to-day operation of the activated sludge process involves a variety of activities. Observations by the operator must be recorded. Laboratory test must be performed along with microscopic examination of the activated sludge. The dynamic, biological system must be kept alive and operating. Different process modes of operation are available to meet different constraints and needs. Methods for regulating the activated sludge must be systematically followed. Finally, the process must be carefully monitored to ensure proper conditions are maintained and stop any problems from developing.

Item	Location	Equipment	Unit	Control
1	Primary Screen	• Mechanical Screen • Conveyor	1 1	Timer Timer
2	Pump Station	• Raw Sewage Pump • Electric Chain Hoist • Ventilation Fan • Sump Pump	4 1 1 1	Float Switch Push Button Timer Float Switch
3	Secondary Screen	• Conveyor • Mechanical Screen	1 1	Timer Timer
4	Grit Chamber	• Motor Drive Unit • Air Lift Pump • Static Screen	1 1 1	Timer Manual Non-electrical
5	Oil & Grease Chamber	• Grease Scum Scraper Blade • Grease Collection	1 1	Timer Timer
6	Anoxic Zone	• Mixer	2	Timer
7	Aeration Tank	• Blower c/w Air Diffuser • Recycle Pump	3 2	Timer/Relay Timer
8	Sedimentation (Clarifier)	• Circular Scrapper • Recycle Sludge Pump • Gravity Sludge Thickener • Recycle Sludge Pump	2 4 1 2	Timer Timer Timer Timer
9	Sludge Dewatering Facilities	• Polymer Dosing Pump • Dewatering Sludge Pump • Filter Press • Sludge Drying Bed	1 1 1 1	Operation by manually

Table 2-2: Equipment of sewage treatment plant

Item	Unit Process	Function
PRIMARY TREATMENT		
1	Primary Screen	• To remove solid and indigestible material from incoming raw sewage.
2	Pump Station	• To lift raw sewage from wet well to treatment facilities.
3	Grit Chamber	• To remove grit in raw sewage.
4	Oil & Grease	• To remove oil and grease in raw sewage.
SECONDARY TREATMENT		
5	Anoxic	• The process by which nitrate nitrogen is converted biologically to nitrogen gas in the absence of oxygen. • This process is also known as anaerobic denitrification. • Gaseous product that can be release into the atmosphere
6	Aeration	• Aerobic treatment of wastewater is the use of oxygen by microorganisms to digest the wastewater.
7	Sedimentation	• Separation from water by gravity settling of suspended solid that is heavier than water. • To produce a clarifier effluent and to produce sludge with a solid concentration that can be easily handled and treated.
SLUDGE TREATMENT		
8	Sludge Dewatering facilities	• To produce 8% to 10% solid contents dewatered sludge before transfer to sludge drying bed/filter press. • To allow the proper ventilation on site storage for 30 days of dried sludge cake.
TERTIARY TREATMENT		
9	Chlorination Tank	• To reduce or remove pollutants before discharging to perimeter drain.

Table 2-3: Unit process description at UTP's STP

2.2 Activated Sludge – The Microbiology

Activated sludge can be defined as "a mixture of microorganisms which contact and digest bio-degradable materials (food) from wastewater." It is consists of a mixed community of microorganisms that metabolize and transform organic and inorganic substances into environmentally acceptable forms. The typical microbiology of activated sludge consists of approximately 95% bacteria and 5% higher organisms (protozoa, rotifers, and higher forms of invertebrates). These single celled organisms grow in the wastewater by consuming (eating) bio-degradable materials such as proteins, carbohydrates, fats and many other compounds. The term "activated sludge" refers to a biological process. This process cannot be monitored without using a biological tool: the microscope because bacteria have a diameter of approximately 0.001 mm. The human eye cannot distinguish objects smaller the 0.1 mm [Richard, M., G.].

Enzymes are compounds that are made by living organisms. Their purpose is to help biochemical reactions to occur. Almost all biochemical reactions require the presence of enzymes to cause the reaction to occur. Enzymes help bacteria in the process of breaking down nutrients, and in rebuilding broken down nutrients into the new compounds that they require for growth and reproduction. Enzymes only do what they are supposed to when environmental conditions are right. If the conditions are not right the enzymes will not function properly, thus, the bacteria will not function properly, and they will not survive. If conditions are right the bacteria will live and prosper [Richard, M., G.].

When there is plenty of food available, bacteria use the food mostly for growth and some for energy. A growing bacterium has flagella (hair-like structures on the outside of the cell) which make it motile, able to move in search of food. A bacterium reproduces into two bacteria. The cell splits into two smaller cells and this process occurs over and over again. When there is very little food available, the bacteria use the limited food to produce energy and to maintain the cell. Very little is available for growth so less reproduction occurs. With little food available, and in an attempt to conserve energy, the bacterium loses it flagella and thus, its motility. The waste products start to form a thick slime layer outside the cell wall, making the cells stick together [Richard, M., G.].

The growth characteristics of bacteria are better understood by studying the growth curve.

- *Lag-phase* During this phase bacteria become acclimated to their new surroundings. They are digesting food, developing enzymes and other things required for growth.
- *Accelerated Growth-phase* The bacteria are growing as fast as they can, since there is an excess of food. The cells are mostly dispersed, not sticking together.
- *Declining Growth-phase* Reproduction slows down because there is not an excess of food. A lot of food has been eaten and there are now a large number of bacteria to compete for remaining food, so the bacteria do not have enough remaining food to keep the growth rate at a maximum.
- *Stationary-phase* The number of bacteria is the highest possible, but not much food is left, so the bacteria cannot increase in number. There is some reproduction, but some cells are also dying, so the number of bacteria remains relatively constant. The bacteria have now lost their flagella and have a sticky substance covering the outside of the cell, allowing them to agglomerate into floc. In fact, the floc get big enough that if aeration and mixing were stopped, the floc could settle to the bottom.
- *Death-phase* The death rate increases with very little if any growth occurring. Therefore, the total number of living bacteria keeps reducing. The bacteria are just trying to keep alive.

A process parameter commonly used to characterize process designs and operating conditions is the food to microorganism (biomass) ratio (F/M). In order for the activated sludge process to operate properly, there must a balance between food entering the system (as measured by BOD or COD) and microorganisms in the aeration tank. The best F/M ratio for a particular system depends on the type of activated sludge process and the characteristics of the wastewater entering system. COD is sometimes used as the measure food entering the system (if there is generally a good correlation in BOD and COD characteristics of the wastewater). Since the COD test can be completed in only a few hours, compared with 5 days for BOD test, the COD more accurately reflects the current food loading on the system [Richard, M., G.] Food / Microorganism Ratio (F/M) can be calculated by using equation 2.1:

$$F/M = \frac{\text{BOD, lbs/day}}{\text{MLVSS, lbs}} \qquad (2\text{-}1)$$

The F/M ratio tells us something about growth and cell condition. If the F/M ratio is high, the bugs normally grow quite rapidly (because this means there is a lot of "food" available in comparison to the amount of microorganism); if the F/M ratio is low, the bug normally grow very slowly (because little food is available for growth)[Joanne Kirkpatrick Price].

As bacteria begin growing, they generally develop into small chains or clumps. They are very active and motile and it is difficult for them to settle. They have not yet developed the slime layer which aids in their sticking together. So, when mixing occurs, the small chains or clumps are broken up and the bugs are dispersed, and they will not flocculate or settle. As the sludge is allowed to age, the bugs lose their motility and accumulate more slime. Then the clumps and chains are better able to stick together. The clumps grow bigger and bigger until they form a floc. If the organisms are allowed to develop properly, under the right conditions, the floc get large and compact and begin to settle. The mixing in the aeration tank tends to keep the floc small since, even though the bugs are sticky, the bond formed holding the organisms together is not very strong. This is good because it allows the cells, food, and oxygen to contact each other [Richard, M., G.].

Microorganisms need oxygen to live. Oxygen is required by these bugs to metabolize food for cell maintenance and growth. Although the bugs need oxygen, some bugs can get along with less oxygen than others. Each bug must have dissolved oxygen of at least from 0.1-0.3 mg/L to function properly. So, it is important to maintain about 2 mg/L of D.O. in the activated sludge so that the bacteria that are contained in the floc can get oxygen. If the DO is less than 2 mg/L, the bugs on the outside of the floc use the DO before it can get to the center of the floc. If this happens, the bugs in the center may die causing the floc to break up [Richard, M., G.].

2.3 Activated Sludge – Protozoa & Rotifers

The presence of particular types of protozoans is related to effluent quality and plant performance. Protozoan play secondary but important role in purification of aerobic wastewater. The protozoans in the activated sludge treatment process fall into four major classes: amoebae, flagellates, and ciliates (free-swimming, crawling, and stalked) [J.B. Copp, P.L. Dold].

Amoebae Amoebae are the most primitive, single-celled protozoans. It move by false feet and frequently present in raw influent, and their presence is short in the aeration basin. Amoebae can only multiply when there is an abundance of nutrients in the aeration tank. It also move very slowly and it is difficult for them to compete for food the there is a limited amount available. They are only dominant in the aeration basin for a short time. When amoeba is present in large numbers in the aeration basin this usually indicates that there has been some sort of shock loading to the plant (there must be a lot of food available). Their presence may also indicate that there is a low D.O. environment in the aeration basin, because they can tolerate very low amounts of D.O [J.B. Copp, P.L. Dold].

Flagellates Most flagellates absorb dissolved nutrients. Soon after amoebae begins to disappear and while there is still high concentrations of soluble food. Flagellates and bacteria both feed on organic nutrients in the sewage so as the nutrient level declines they have difficulty out competing the bacteria for soluble food so, their numbers begin to decrease. If large amounts of flagellates are present in the later stages of the activated sludge development this usually indicates that the wastewater still contains a large amount of soluble organic nutrients [J.B. Copp, P.L. Dold].

Ciliates Ciliates feed on bacteria not on dissolved organics. While bacteria and flagellates compete for dissolved nutrients, ciliates compete with other ciliates and rotifers for bacteria. The presence of ciliates indicate a good sludge, because they dominate after the floc has been formed and after most of the organic nutrients have been removed [J.B. Copp, P.L. Dold].

Free-swimming ciliates - These ciliates appear as flagellates begin to disappear. As the bacterial population increases, a lot of dispersed bacteria is available for feeding and as a lightly dispersed floc appears, free-swimming ciliates begin to dominate and feed on the increased numbers of bacteria [J.B. Copp, P.L. Dold].

Crawling ciliates - As floc particles enlarge and stabilize, crawling ciliates graze on floc particles. Crawling ciliates out compete free-swimming ciliates for food because they can find food within the floc [J.B. Copp, P.L. Dold].

Stalked ciliates - Stalked ciliates appear in the mature sludge. Within the mature sludge the crawling and stalked ciliates compete for dominance [J.B. Copp, P.L. Dold].

2.4 Activated Sludge – Process Control

Microscopic examinations of activated sludge can help to assess the condition of the biomass in an aeration basin and the settleability of the sludge. It can also aid in the identification of filamentous bacteria that may cause problems in wastewater treatment plants [M.Puteh, K. Minekawa, N. Hashimoto, Y. Kawase].

Floc Particles: Sizes and Shapes When floc particles first develop in the activated sludge process, that is, at a relatively young sludge age, the particles are small and spherical. Because filamentous organism do not develop or elongate at relatively young sludge ages, the floc-forming bacteria can only "stick" or flocculate to each other in order to withstand shearing action. Bacterial flocculation and the absence of filamentous organisms result in spherical floc particles. As the sludge age increases and the short filamentous organism within the floc particles began to elongate, the floc forming bacteria now flocculate along the lengths of the filamentous organisms. These organism provide increased resistance to shearing action and permit a significant increase in the number of floc-forming bacteria in the floc particles. The presence of long filamentous organisms results in a change in the size and shape of floc particles. The floc particles increase in size to medium and large and change from spherical to irregular [M.Puteh, K. Minekawa, N. Hashimoto, Y. Kawase].

Dispersed Growth Dispersed growth is a population of bacteria that is suspended in the liquid portion of the mixed liquor. These bacteria are still growing rapidly and have not begin to flocculate. Most dispersed growth is bacterial. Only a little dispersed growth should be present in a properly operating activated sludge process. Ciliated protozoa play an important role in the removal of dispersed growth. Dispersed growth is also removed from the bulk medium by its adsorption to the surface of floc particles. A significant amount of dispersed growth is present at the start-up of an activated sludge process. A lot of food is available, and the bacteria are very active and are multiplying rapidly. The presence of significant or excessive dispersed growth within the mixed liquor can also be due to the interruption of proper floc formation [M.Puteh, K. Minekawa, N. Hashimoto, Y. Kawase].

Operational Considerations The solution usually involves addition of the limiting nutrient, such as ammonia to provide nitrogen, or phosphoric acid to provide phosphorus. There is usually enough nutrient if the ammonia plus nitrate in filtered (0.45 um) effluent is greater than 1 mg/L and the soluble orthophosphate is greater than 0.5 mg/L. However, in cases where easily degradable, soluble BOD is available, higher N and P concentrations may be necessary [M.Puteh, K. Minekawa, N. Hashimoto, Y. Kawase].

2.5 STP's Problems

There are few problems encountered on the STP operation after conducted an investigation for about 5 months;

a) The malfunction of the scrapper's turbine for both of the clarifiers

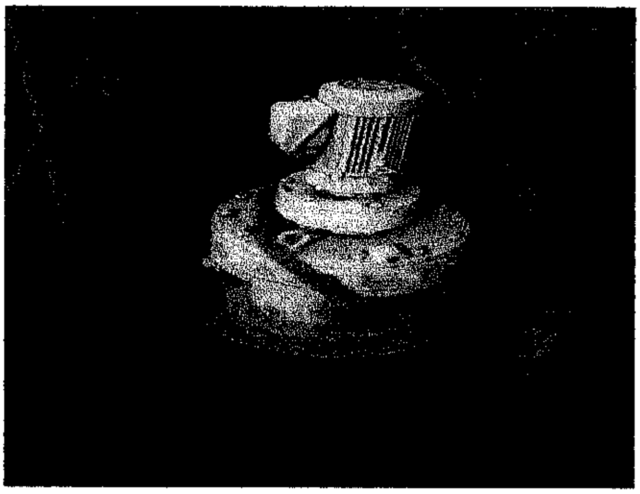


Figure 2-2: Malfunction Turbine

b) Return Activated Sludge pump (RAS) were malfunction. Hence, there was no sludge returned from the clarifier to the aeration tank. Return sludge is very essential in wastewater treatment plant because it contains organic solids and live microbes. The microbes feed on the organic material that is contained in the primary effluent.

c) Malfunction of rotating grit chamber (to filter wastewater). Hence, sometime large particle waste materials such as rocks, branches, pieces of lumber, leaves, paper, tree roots, plastics, rags, bottles and etc are flowed into the aeration tank.

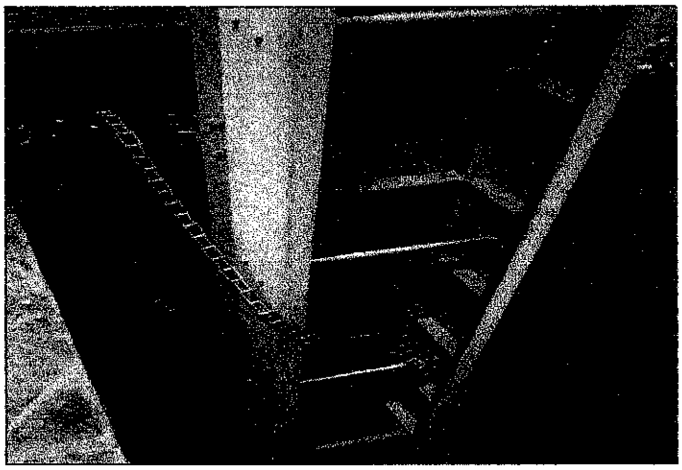


Figure 2-3: Malfunction Grit Chamber

d) Large particles in the aerations tank due to malfunction of grit chambers

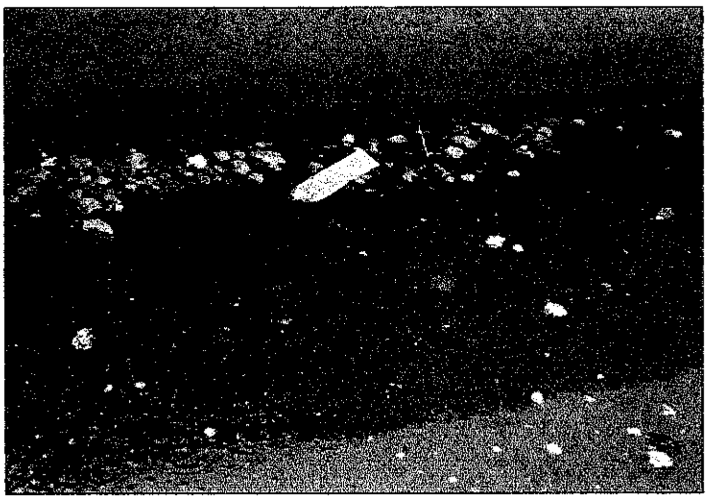


Figure 2-4: Accumulated waste material in aeration tank

e) Insufficient height of the inlet chamber in the primary grit chamber

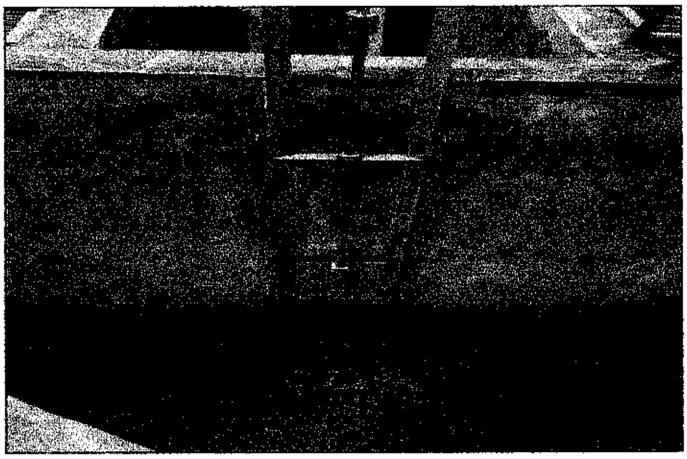


Figure 2-5: Insufficient height of grit chamber

f) Algae growth in the clarifiers

It is found that there was floated sludge on the clarifier's surfaces occurred in the pilot plant clarifier. These suggested that nitrification process occurred in the clarifier. The sludge was pushed up by nitrogen released from the breakdown of ammonia through denitrification process. Figure below showed accumulated algae in clarifier:

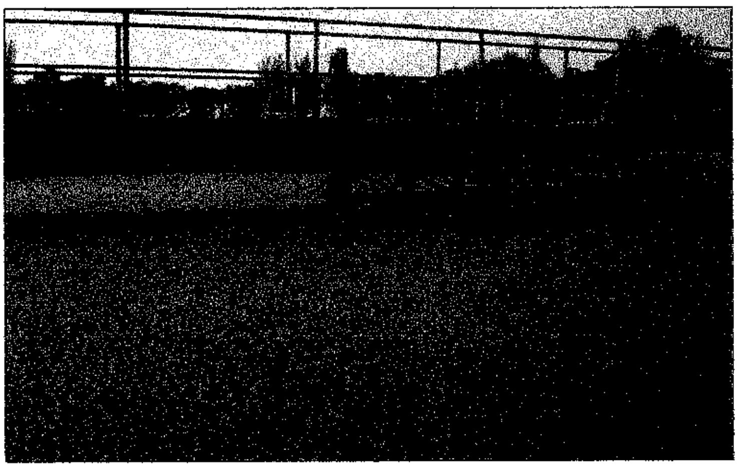


Figure 2-6: Algae growth in clarifier

2.6 Total Suspended Solid (TSS)

Total Suspended Solids is a portion of organic and inorganic solids that are removed by filtration process. Total suspended solids (TSS) in wastewater may be caused by sand, silt, clay and organic matter. These are filterable solids removed with a filter having particle retention of 1.5 μm [Metcalf & Eddy, 1991]. The typical total suspended solids concentration in the municipal wastewater is approximately about 230 mg/L. When total suspended solids are discharged into the natural waters, it may increase turbidity of the water and when they settle to the bottom may ruin the spawning and breeding grounds of aquatic animals. Organic solids that have been settled down at the bottom will decompose progressively using up dissolved oxygen and produce noxious gases [Mogens Henze, Erik Arvin].

2.7 Sludge Volume Index (SVI)

Settling characteristics of mixed liquor suspended solids must be considered when evaluating aeration tank. Two commonly used measures developed to quantify the settling characteristics of the activated sludge volume index (SVI) and the zone settling rate. The SVI is the volume of 1 g of sludge after 30 minutes of settling. The SVI is determined by placing a mixed liquor sample in a 1 to 2 liter cylinder and measuring the settled volume after 30 minutes and the corresponding sample MLSS concentration [Mogens Henze, Erik Arvin]. The numerical value is computed using the following expression:

$$\text{SVI} = \frac{(\text{Settled volume of sludge, mL/L})(10^3\ \text{mg/g})}{(\text{Suspended solids, mg/L})} = \frac{\text{mL}}{\text{g}} \qquad (2\text{-}2)$$

The SVI test is a somewhat subjective indicator as it does not take into account the MLSS concentration. The SVI is an attempt to define a more absolute indication of the sludge settling potential. For plants operating on industrial wastewaters satisfactory SVI values are often in the range 100 to 200; municipal wastewater treatment plants tend to have lower SVI values. The sludge volume index parameter indicates the settling and thickening characteristics of the activated sludge. Therefore, the quality of the sludge is directly reflected in the decline of this parameter. In addition, changes in the sludge volume, sludge concentration, sludge loading, and sludge age will affect the sludge volume index [Mogens Henze, Erik Arvin].

There is also a direct correlation between the sludge volume index and the settling rate. The higher the settling rate, the lower the sludge volume index. In order to identify the development of sludge changes it is important to monitor the sludge volume index, the sludge volume and the solids concentration in the aeration basin and return activated sludge [Mogens Henze, Erik Arvin].

CHAPTER 3

METHODOLOGY

3.1 Pilot Plant Preparations

Before carry out laboratory works, pilot plant was filled or fed manually with the wastewater from UTP's STP about three times in a week and laboratory works were done about two times in a week. Then, the exact UTP's STP flowrate and retention time is scaled down with the pilot plant requirement. The pilot plant dimensions are (2000 x 900 x 1800) mm with weight of 280 kg. Pilot plant feeder tank was filled with wastewater from STP anoxic zone; the pilot plant aeration tank was filled with wastewater from STP's aeration tank while pilot plant clarifier was filled with water from STP's clarifier. The volume filled in pilot plant aeration tank was 300 liter.

For the first the study period, valve 3 (V3) was closed to simulate the same condition as STP (currently STP was operated under no sludge recycle). However, after the project has entered second study period, valve 3 was open to allow the pilot plant to operate in normal condition, where there is return activated sludge from clarifier to aeration tank. Moreover, during the second study period (valve 3 was opened) segregated chemical waste from chemical blocks 4 and 5 was added into the feeder tank along with wastewater by stages. The first stage consists of 20% segregated chemical waste added into 400 liter of wastewater for 2 weeks. Then, the amount was increased to 50% of segregated chemical waste added into 400 liter of wastewater for the last 3 weeks. The objective of adding the segregated chemical waste into pilot plant feeder tank along with normal wastewater is to measure whether there are changes in pilot plant effluent quality and performances of the mixed segregated chemical waste with normal wastewater.

The microorganism observations cannot be done because the microscope cannot record any picture due to software problems. TSS tests are done to measure the level of suspended solids concentration in the plant. The Sludge Volumetric Index test (SVI) also was done to measure settleable suspended solids in 1 liter of wastewater in 30 minutes period of time.

3.2 Sampling Method

In order to measure the performance of UTP's STP (aeration tank and clarifier), 3 points were selected along the sewage treatment plant; (1) influent of anoxic zone, (2) effluent of clarifier and (3) effluent of aeration tank; and along the activated sludge wastewater treatment pilot plant; (1) influent feeder tank, (2) effluent of aeration tank, and (3) effluent of clarifier tank for sampling purposes. Samples taken from the collection point from aeration tank pilot plant are to be tested on site using 30 minutes settleability test. The parameters that have been studied for this project is mixed liquor suspended solids or activated sludge (MLSS) and Sludge Volume Index (SVI). By using wastewater sample from UTP's STP and activated sludge wastewater treatment pilot plant, a series of comparison between those results are made. Thus, the characteristic and performance of UTP's STP can be evaluated. **Figure 3.1** below shows the sample collection points in the pilot plant:

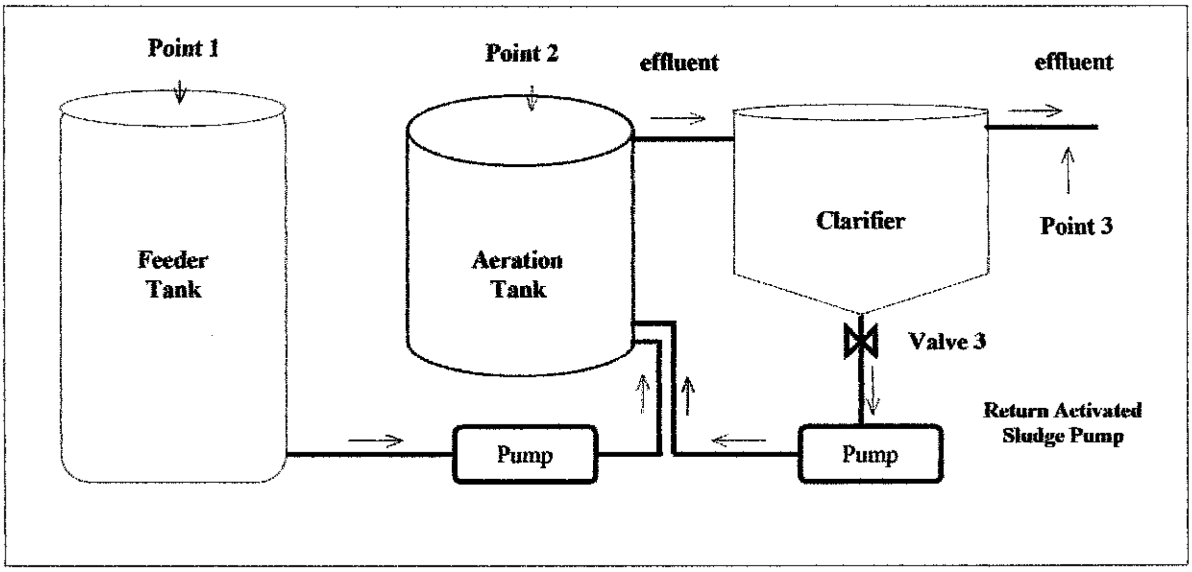


Figure 3-1: Pilot plant sample schematic diagram and collection points

These samples are taken once in a week from both plants; UTP's STP and activated sludge wastewater treatment pilot plant. **Table 3-2** below showed wastewater collection samples points:

SOURCE	PARAMETER	SAMPLE TYPE	FREQUENCY
Influent of anoxic zone from UTP's STP	TSS	Grab	Once in a week
Effluent of clarifier from UTP's STP	TSS	Grab	Once in a week
Effluent of aeration tank from UTP's STP	TSS	Grab	Once in a week
Influent of pilot plant feeder tank	TSS	Grab	Once in a week
Effluent of pilot plant aeration tank	TSS / MLSS	Grab	Once in a week
Effluent of pilot plant clarifier	TSS	Grab	Once in a week

Table 3-1: Points of wastewater sample for both plants

3.3 Total Suspended Solids Laboratory Work Procedure

Total Suspended Solids or TSS purpose is to determine the weight of suspended solids existed in samples. The procedures or steps are done as follows; the weight of aluminum foils, with and without filtration paper was measured. Then, 500 ml of samples were mixed from the sample bottles. Three measurement cylinders were used to measure 50 ml of samples from 500 ml of samples in the beaker.

By using forceps, the filtration paper was placed on the volumetric cone for the filtration process. A clapper was used to clap the filtration cylinder on the volumetric cone. The sample from 50 ml of cylinder was pour into the filtration unit (The vacuum pump was already on during this process). After 10 minutes, the filter paper was removed from the filtration unit and put into the aluminum foil to be weighted. The weighted filter paper and aluminum foil was then dried in oven for 20 minutes in dessicator to stabilize the samples.

The dried filter paper with aluminum was then being measured once again and recorded.

The process was repeated for all points. Formula below is used to calculate Total Suspended Solids (TSS) result:

$$TSS = (X - Y) / Z \qquad (3\text{-}1)$$

Where; X = Weight of dry sample + Weight of aluminum foil

Y = Weight of aluminum foil + Weight of filter paper

Z = Volume of wastewater sample

Before carrying out the experiment, few factors must be taken care of in order to get a pure result and to avoid error which is; to wear glove throughout the experiment; the filtration paper and the aluminum foil should not be touched by hands and stirrer was used to stir the sample from the sampling bottles in the beaker and stir the sample that being poured into the filtration unit to ensure that all suspended solids are not being suspended.

3.4 Sludge Volume Index (SVI) Procedures

The sludge volume index (SVI) is the volume in milliliters occupied by 1 g of a suspension after 30 min settling. SVI typically is used to monitor settling characteristics of activated sludge and other biological suspensions. 1 Although SVI is not supported theoretically, experience has shown it to be useful in routine process control.

The procedure to perform SVI test on site is pour 1 liter of sample from aeration tank to a 1 liter beaker. Then, the beaker was leave for 30 minutes. After 30 minutes, the suspended solids suspended beneath the beaker were measured.

The samples were taken to the laboratory and by using the same sample from the beaker, TSS test was done.

CHAPTER 4

RESULTS AND DISCUSSION

In order to measure Total Suspended Solids (TSS) and sludge settleability from Sewage Treatment Plant and Pilot Plant, series of laboratory experiments have been done. After that, results obtained from each experiment were analyzed to evaluate the performance and characteristics of the wastewater.

4.1 Total Suspended Solids (TSS) Results

After completed the Final Year Project period which consist about four and half months, twenty TSS tests have been done in order to evaluate the performance of Sewage Treatment Plant. Ten tests were conducted using wastewater sample taken from pilot plant intake points and the other ten tests were conducted using wastewater sample taken form Sewage Treatment Plant intake points. For pilot plant, five tests were conducted under the condition of no sludge recycle in activated sludge and five tests were conducted under the condition of allowing sludge recycle in activated sludge addition with chemical waste solution discharge from Chemical Block 3 and 4. Meanwhile for Sewage Treatment Plant, five tests were conducted before the oxidation pond wastewater was diverted to Sewage Treatment Plant and five tests were conducted after the oxidation pond wastewater was diverted to Sewage Treatment Plant. The tests are conducted using 50 ml and 25 ml (mostly 25 ml) of sample volume for each point and four to five readings were taken from the experiments to evaluate the consistency of results obtained.

4.11 Sewage Treatment Plant Total Suspended Solids (TSS) Results

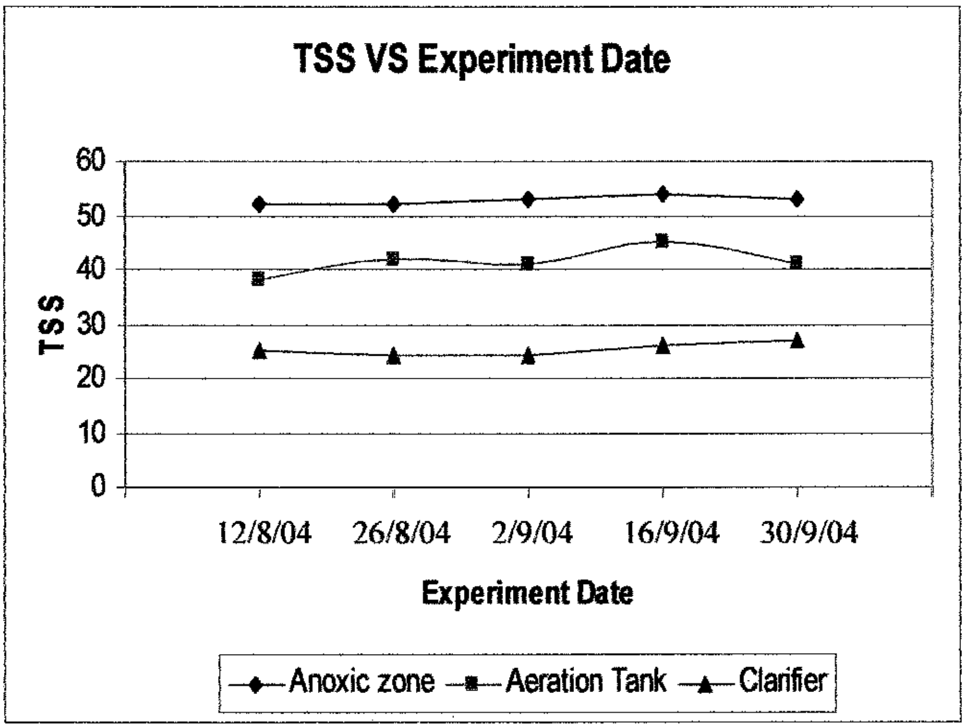


Figure 4-1: Graph indicate TSS results for STP before mix with oxidation pond wastewater

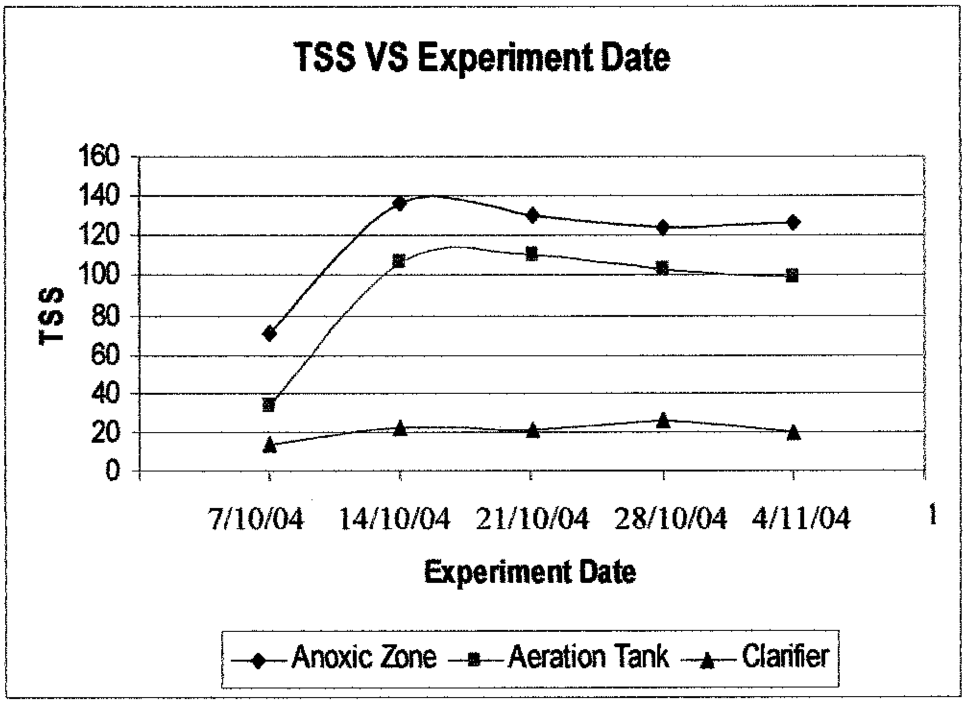


Figure 4-2: Graph indicate STP TSS results after mixed with oxidation pond wastewater

Figure 4-1 showed TSS results for Sewage Treatment Plant obtained before oxidation pond wastewater was diverted to Sewage Treatment Plant while **Figure 4-2** showed TSS results for Sewage Treatment Plant obtained after oxidation pond wastewater was diverted to Sewage Treatment Plant. For Sewage Treatment Plant, the average TSS results (refer **Figure 4-1**) obtained from five experiments are 53 mg/l for anoxic zone, 41 mg/l for aeration tank and 25 mg/l for clarifier. The average TSS results for anoxic zone ranged from 52 mg/l (lowest result) to 54 mg/l (highest result) from experiment 1 (12/8/04) to experiment 5 (30/9/04). After wastewater from oxidation pond was diverted to STP on 2nd October 2004, TSS results for anoxic zone have increased as high as 137 mg/l (refer **Figure 4-2**). The average results obtain from experiment 7 (14/10/04) to experiment 10 (4/11/04) was 130 mg/l. This situation might occur due to suspended solids in oxidation pond wastewater are mixed with available suspended solids in anoxic zone that result in high amount of total suspended solids. Result for experiment 6 (7/10/04) was not included in the average calculation because the samples are taken during non-peak hours (at 3 pm) while the others are taken during peak hours (at 10 am), where high amount of wastewater are flowed into STP intake point.

However, these values can be considered as low because the theoretical value for TSS at influent should be around 250 mg/l to 300 mg/l. As mention earlier the design basis for flow rate on this plant is about 5,175.00 m^3/d or 23,000 population equivalent. The insufficient amount of suspended solids may due to over design of the treatment plant where the capacity size of the treatment plant is too big for small amount of influent, since the population of UTP residents was about 6000 to 7000 peoples. Moreover, not all wastewater discharge from UTP buildings was channeled into the Sewage Treatment Plant. The Sewage Treatment Plant only covered old USM buildings, maintenance building and new village buildings.

The average TSS results obtained from aeration tank for both periods showed decreased in value compared with the anoxic zone results. An average TSS value varied from 38 mg/l to 45 mg/l from experiment 1 (12/8/04) to experiment 5 (30/9/04) and 99 mg/l to 110 mg/l from experiment 7 (14/10/04) to experiment 10 (4/11/04). Since the design requirement for MLSS in aeration should be in the range of 3000 mg/l to 4000 mg/l, therefore the results obtained from total nine experiments were out from the design requirement. This condition might related with the size of aeration tank and dissolve oxygen supplied. The contents of the aeration tanks should delicate balance of food and oxygen supplied. However, the huge size of aeration tank may facilitate the organic matter to settle down at the bottom of the tank. Moreover, the oxygen is being released in high concentration in the tank since there is no control panel to control precisely amount of oxygen in the tank. This situation might cause the inter-connection bonding of organic matter easily break-up in to small constituent and diluted in the wastewater when mixed, aerated and maintained in suspension with dissolve oxygen. It also tends to invite oxidation process to occur. An important summary statement is that during combustion / metabolism of organic waste, oxygen is used and carbon dioxide is a product. In aeration tank, portion of waste is oxidized to end products to obtain energy for cell maintenance and synthesis of new cells. Simultaneously, some of waste is converted into new cell tissue using part of the energy released during oxidation. Finally, when organic matter is used up, the new cells begin to consume their own cell tissue to obtain energy for cell maintenance. This is also called as endogenous respiration [Metcalf & Eddy]. The processes can be described by chemical reactions:

Oxidations

$COHNS + O_2 + \text{bacteria} \rightarrow CO_2 + H_2O + NH_3 + \text{other end products} + \text{energy}$ (4-1)

Synthesis

$COHNS + O_2 + \text{bacteria} + \text{energy} \rightarrow C_5H_7NO_2$ (new tissue) (4-2)

Endogenous respiration

$C_5H_7NO_2 + 5O_2 \rightarrow 5CO_2 + NH_3 + 2H_2O$ (4-3)

Note that COHNS represent the elements of carbon, oxygen, hydrogen, nitrogen, and sulfur which is representing organic waste and $C_5H_7NO_2$ (Propose by Hoover and Porges 1952) representing cell tissue [Metcalf & Eddy].

The effluent of STP clarifier varies from 24 mg/l to 27 mg/l from experiment 1 (12/8/04) to experiment 5 (30/9/04) with average results are 25 mg/l; and 20 mg/l to 26 mg/l from experiment 7 (14/10/04) to experiment 10 (4/11/04) with average results are 22 mg/l. These results shows that all the effluents are still in the limit stated by DOE for both Standard A (20mg/l BOD, 50 mg/l TSS) and Standard B (50mg/l BOD, 100 mg/l TSS) even though the process of treatment was not properly executed. This condition might occur with the help of huge size of aeration tank and excessive oxygen supplied that leaved low concentration of suspended solids discharge into the clarifier. Although STP was received additional wastewater from oxidation pond but the results is still in the limit stated by DOE. Once again this condition might occur due to huge size of clarifier and deep depth that allow the suspended solids to settle easily.

Theoretically, it should be large variation of result between clarifier and aeration tank because suspended solids that entered to the clarifier was low of concentration in organic matter. It is found that percentage of suspended solids reduction from aeration tank to clarifier in **Figure 4-1** (which is 39%) is low compared to results obtained in **Figure 4-2** (which is 79%). Low percentage of suspended solids reduction in **Figure 4-1** is occur due to accumulated scum or algae on the wastewater surface of clarifier sample intake point that make weight of suspended solids retained on the filter paper increased.

4.12 Pilot Plant Total Suspended Solids (TSS) Results

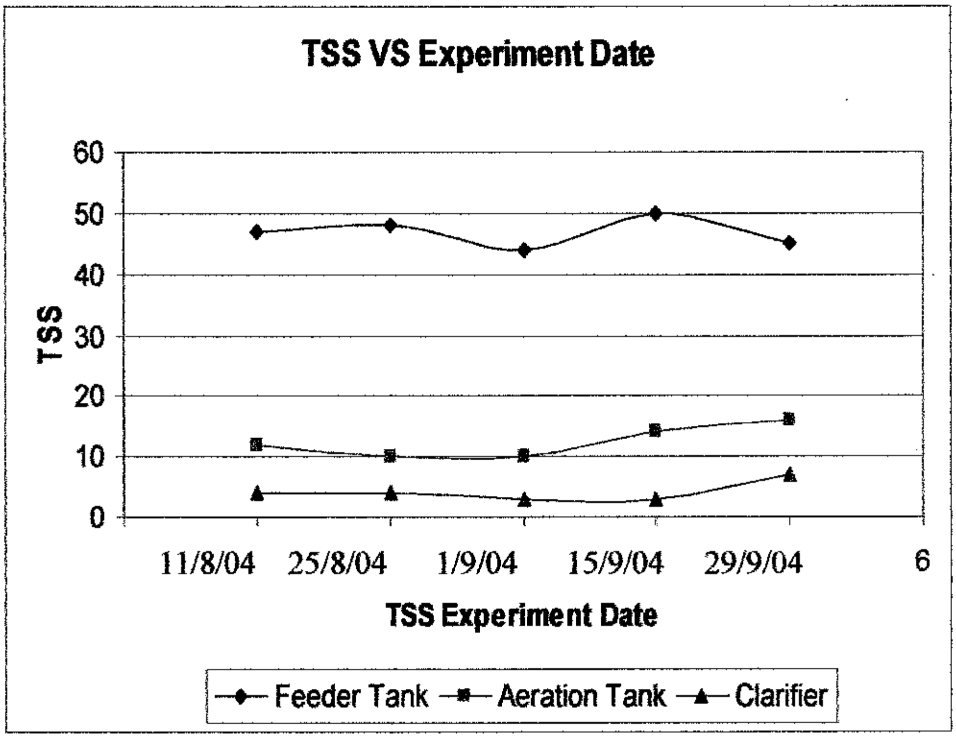
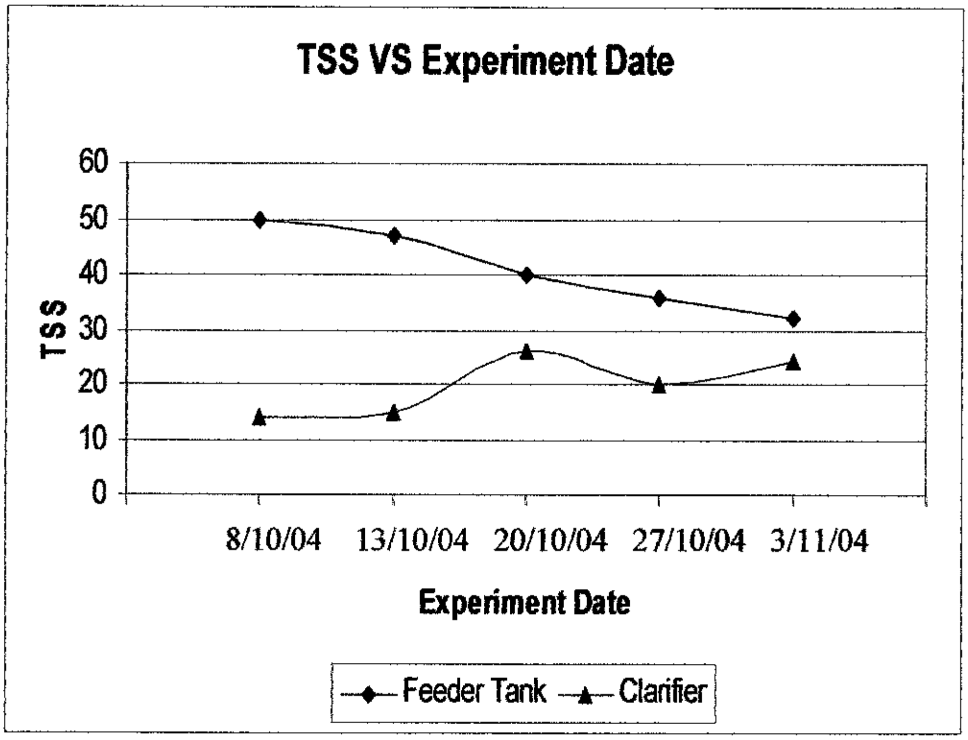


Figure 4-3: Graph indicates TSS results for pilot plant (no sludge recycling)



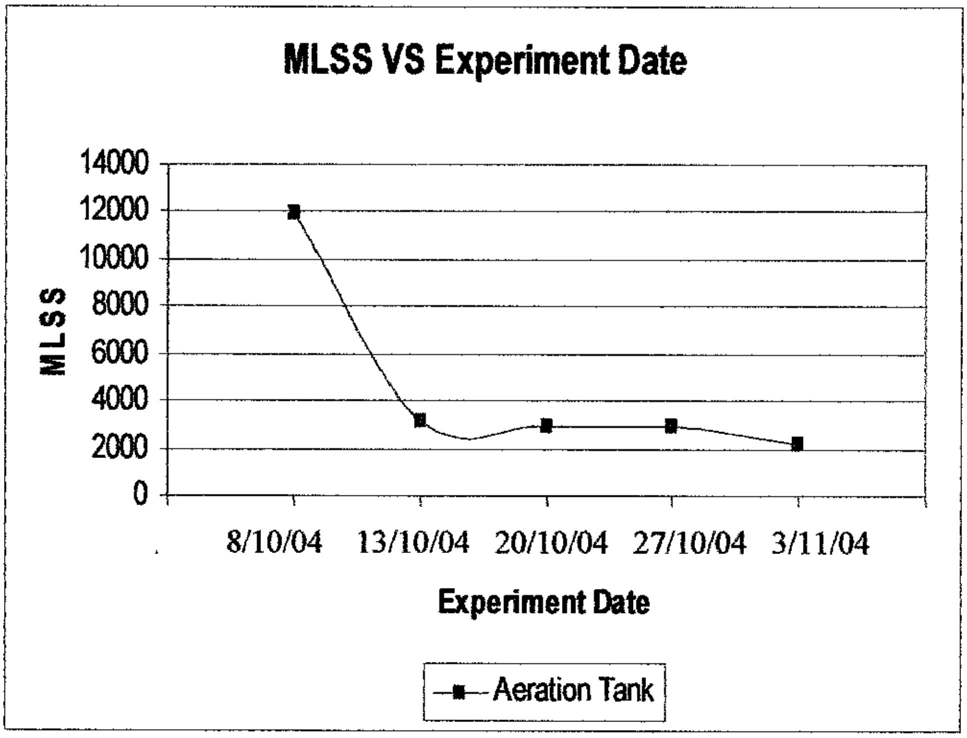


Figure 4-4: Graph indicates TSS results for pilot plant (sludge recycle) addition with waste chemical solution

Figure 4-3 showed TSS results for pilot plant obtained before sludge recycling while **Figure 4-4** showed TSS and MLSS (for clarifier) results for pilot plant obtained after sludge recycling. The TSS results for pilot plant feeder tank ranged from 44 mg/l to 50 mg/l from experiment 1 (11/8/04) to experiment 5 (29/9/04). The average result from total 5 experiments was 47 mg/l. The average result obtained was lowered compare to STP anoxic zone. This condition might occur due the activity of filtration before the wastewater from STP was poured into the feeder tank in pilot plant. The filtration was done to reduce the suspended solids in the wastewater to avoid large suspended solids form stuck at the elbow of pipeline and to avoid pilot plant pump from getting stuck. The long process of transporting the wastewater from STP to pilot plant may also effects the concentration of TSS in the feeder tank. The wastewater was filled in 10 bottles (volume 25 l) and transported by car. Due to vibration during transported, the wastewater may spilled out from the bottles and thus reduced the TSS concentration. In order to keep the suspended solids in the form of small particles, baffle should be installed in the feeder tank. However, the pilot plant used aerated air as substitute for the function of baffle. This situation might effect the TSS concentration since the wastewater was aerated for 24 hours period.

Pilot plant started to have sludge recycle after experiment 5 (29/9/04) was done. After allowing sludge recycle, the average TSS results in experiment 6 (8/10/04) and experiment 7 (3/11/04) are 50 mg/l and 47 mg/l. To provide the Mixed Liquor Suspended Solids (MLSS) same as the requirement of STP design criteria which is 2500 mg/l to 3000 mg/l, 25 liter of sludge from oxidation pond was poured into the pilot plant aeration tank. After that MLSS test was done to measure the MLSS reading. At the first stage, the MLSS results were high from the desired requirement, which is 11920 mg/l. Then by using calculation, MLSS value was reduced to 3200 mg/l (refer appendices for the calculation). In experiment 10 (3/11/04), the MLSS value was quite low, which about 2160 mg/l. This is due to recycle sludge was stuck at the clarifier pipeline that cause large amount of suspended solids settled in the clarifier.

The average TSS results are constant in the ranged of 40 mg/l to 59 mg/l before the addition of chemical wastewater from chemical Blocks 4 and 5. The addition of chemical wastewater was started in experiment 8 (20/10/04) to experiment 10 (3/11/04). The average TSS results were dropped after the addition of 20% chemical waste from the total volume of influent feed into the pilot plant (refer **Figure 4-4**). This might occur due to the dilution the addition of segregated chemical waste to the pilot plant.

The effluent for pilot plant was increased after allowing the sludge recycling environment in aeration tank. The average result obtained from experiment 6 (8/10/04) to experiment 10 (3/11/04) was 20 mg/l which is high than average result obtained from experiment 1 (11/8/04) to experiment 5 (29/9/04). Moreover, the average results keep on increasing after the addition of segregated chemical waste solution (refer experiment 8 (20/10/04) to experiment 10 (3/11/04) average TSS results for pilot plant clarifier). This might be due to the reaction that take place between chemical waste constituent and available bacteria in the aeration tank, that reduce the performance of bacteria activities. These suggest that the chemical waste solution may influence the outcome of wastewater treatment.

4.2 Sludge Volume Index (SVI) Results

Four sludge settleability tests were conducted to evaluate settling quality of the aerated mixed liquor.

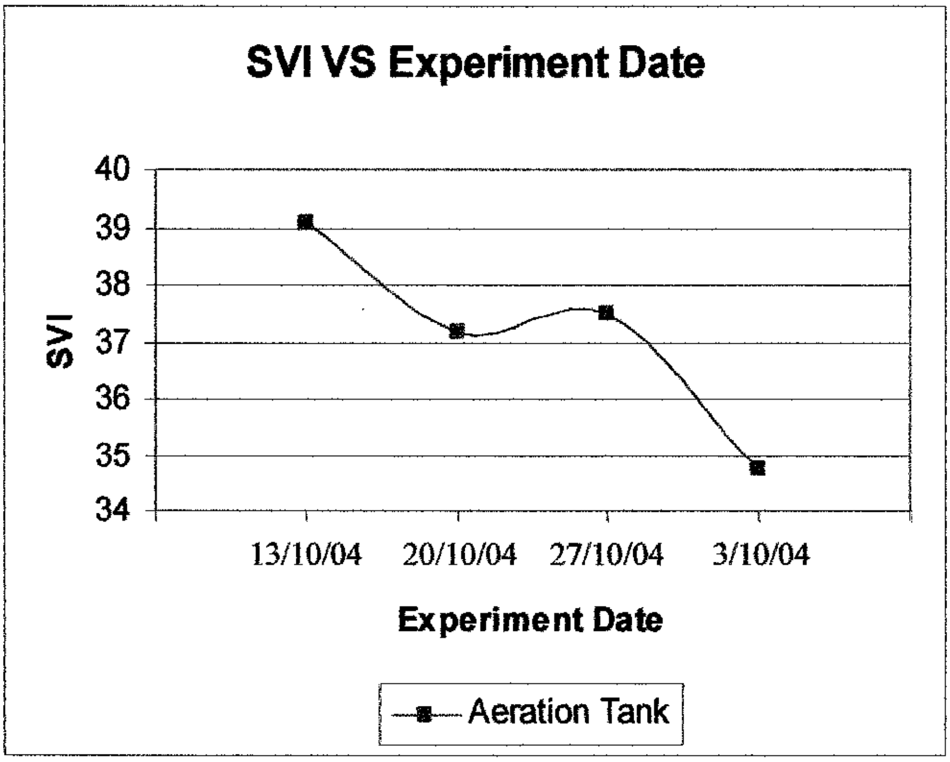


Figure 4-5: Graph indicates SVI results for pilot plant

The SVI test results obtained ranged from 35 ml/g to as high as 39 ml/g. The sludge volume index of activated sludge is defined as the volume in milliliters occupied by one gram of activated sludge after settling for 30 minutes. From this definition it may be observed that the lower the SVI, the better is the settling quality of the aerated mixed liquor. Also, high SVI values (greater than 100) indicate poor settling qualities and possible bulking problems in the secondary clarifier. Sludge with an SVI of less than 100 is considered a good settling sludge. Usually, SVI values above 150 typically associated with filamentous growth [Mogens Henze, Erik Arvin].

Since the results obtained were lower than 100 ml/g, the settling quality of the pilot plant aerated mixed liquor was satisfied. However, despite that SVI is classical measurements of sludge quality, but may or may not always reflect the true sludge conditions and must be compared with other process parameters, such as sludge units.

4.3 Problem Encountered

There are a lot of problems faces during working with the UTP's STP and pilot plant. Below are the problems encountered during study period of the project:

i. Transportation problem. In order to fill up the pilot plant which consists of feeder tank, aeration tank and clarifier with wastewater from UTP's STP, the function of UTP lorry is very important, but for the most of the time, UTP lorry was not available for the student's usage. Due to this problem, the students cannot transport the wastewater to the pilot plant according to their schedule.

ii. Bureaucracy problem. Due to non-availability of UTP lorry, the alternatives that only left by the students were their own transport. Problem arises when the road access to Chemical Block was commonly blocked by security because student's vehicles are not allowed to use the road. Although the students have showed the official letter for using the road but the security was denied the students official letter. Due to this problem, the students cannot transport the wastewater to the pilot plant according to their schedule.

iii. Locations of the pilot plant are too far from the STP cause the transportations problem. In addition, the pilot plant needs to be feed daily with a big amount of wastewater.

iv. Equipment failure such as the Sonde Flowmeter to measure flowrate of the systems.

v. Pilot plant feeder pump failure because of the pipeline that connected wastewater flow from feeder tank to aeration tank was blocked with sludge contain in the feeder tank causing the pump heated after has been sucked too much air. In addition, the pipeline diameter is too small, about 0.5 cm Ø, that cause the sludge easily get clog in the pipeline.

CHAPTER 5

RECOMMENDATION

Although UTP's STP was equipped with filter press, grit chamber, chlorination tank, clarifier, gravity thickener, however these equipments are recently not functioning well. As a suggestion for improvement program, the maintenance department should rectify these malfunction equipment to increase the efficiency of STP operation. Moreover, the STP should be supported with functioning return activated sludge (RAS) pump. Since the function of RAS pump is to allow sludge recycling to the beginning of the aeration process from the bottom of the secondary clarifiers and thus provide ample condition for bacteria to live, maintenance program should be done to rectify the malfunction of RAS pump. The accumulated algae should be removed from the clarifier and 40 days of sludge age must be achieved to allow the degradation of ammonia in the anoxic zone.

CONCLUSION

The main objective of the project is to evaluate the performance of UTP's STP by simulating the UTP's STP process into activated sludge wastewater treatment pilot plant. The pilot plant that consist of feeder tank, aeration tank and clarifier were run under exact conditions like STP for the first 5 weeks by closing valve 3 (V3) to simulate the same condition as STP (no sludge circulation in the current STP operation). After 5 weeks, the V3 valve is open to allow normal operations. Results from both 2 periods will be compared to evaluate the performance of the plant. The parameters that been evaluated are MLSS, bacteria exist and sludge settleability.

The percentage of TSS removal for STP in the first phase (before oxidation pond wastewater diverted to STP) was 53% and increased to 83% in the second phase (after oxidation pond wastewater diverted to STP). Lower percentage of TSS removal in the first phase was due to accumulated scum or algae on the clarifier effluent surface that make weight of suspended solids retained on the filter paper increased and the accumulated scum or algae was cleared from clarifier effluent surface in the second phases. However, result obtained showed that the effluent from STP was met the Environmental Quality Act (EQA), 1974 standard for both phases even though the process of treatment was not properly executed. This is due to excessive oxygen supplied in aeration tank and over design of aeration tank and clarifier.

Meanwhile, the percentage of TSS removal for pilot plant without recycle in activated sludge was 91%. After allowing sludge recycle in activated sludge, the percentage of TSS removal was dropped to 36%. The decreased in result is due to influence of chemical waste effect because during allowing sludge recycle in the activated sludge, 20% of segregated chemical waste was added in the pilot plant. Although only 20% of segregated chemical wastewater being added into the total amount of normal wastewater feed into the pilot plant's aeration tank, it has been increased the concentration of suspended solids in clarifier.

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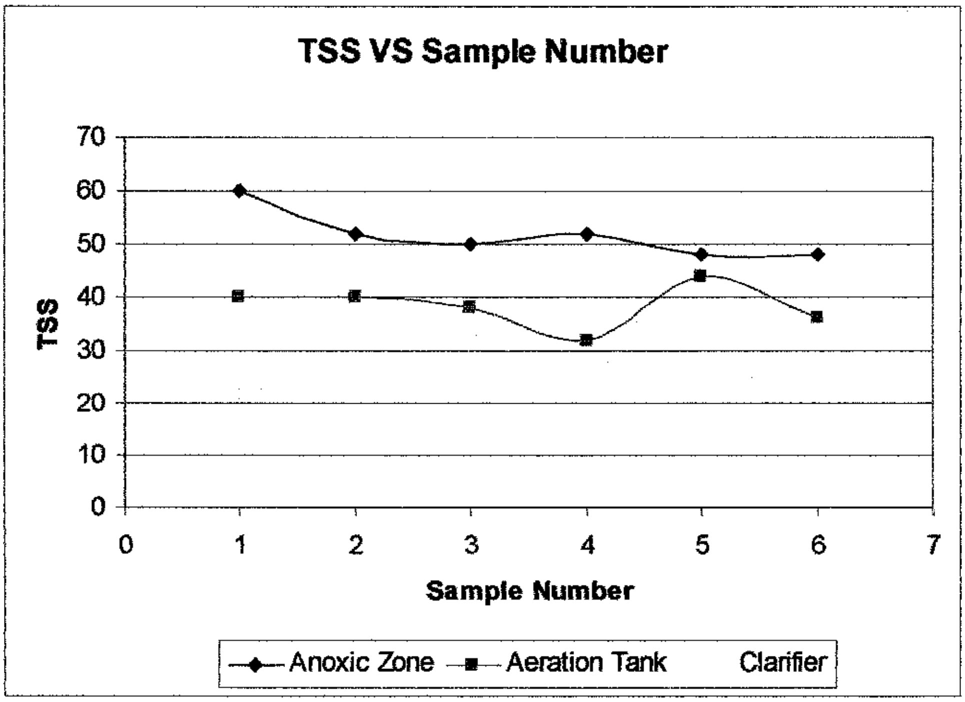
APPENDICES

STP RESULTS

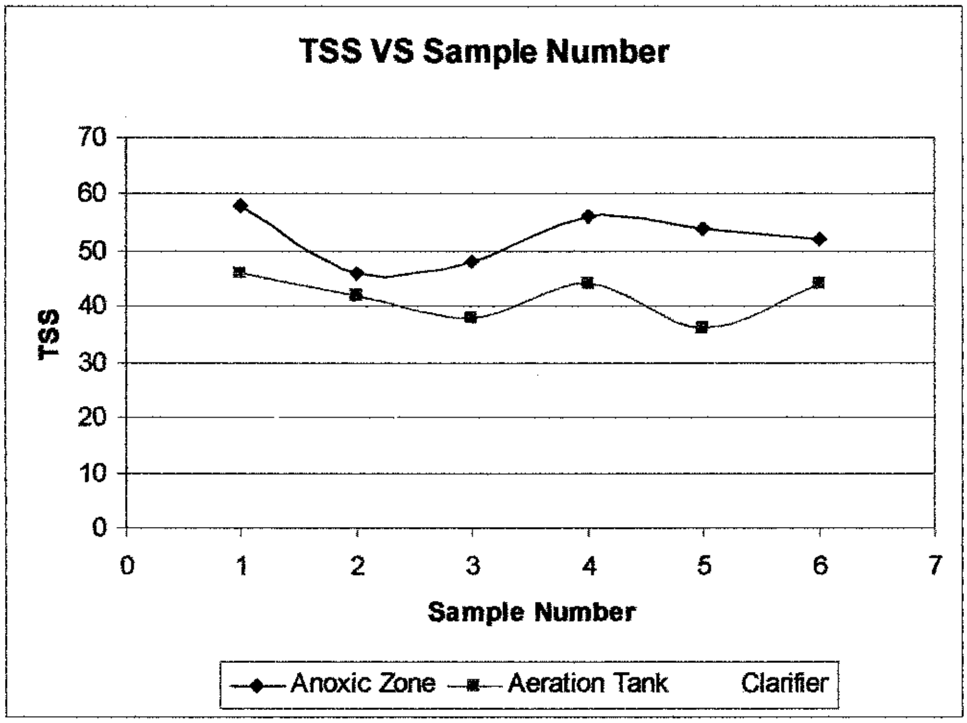
Experiment 1 (12 / 8 / 04)

ıple	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
	50	2.8832	2.8862	60	
	50	2.8775	2.8801	52	
ıder	50	2.9224	2.9249	50	52
ınk	25	2.8758	2.8771	52	
	25	2.8842	2.8854	48	
	25	2.8851	2.8863	48	
	50	2.5690	2.5710	40	
	50	2.5720	2.5740	40	
ation	50	2.5710	2.5729	38	38
ınk	25	2.5643	2.5651	32	
	25	2.5784	2.5795	44	
	25	2.5698	2.5707	36	
	50	2.5600	2.5611	22	
	50	2.5700	2.5713	26	
ifier	50	2.5701	2.5712	22	25
	25	2.5746	2.5753	28	
	25	2.5768	2.5774	24	
	25	2.5658	2.5665	28	



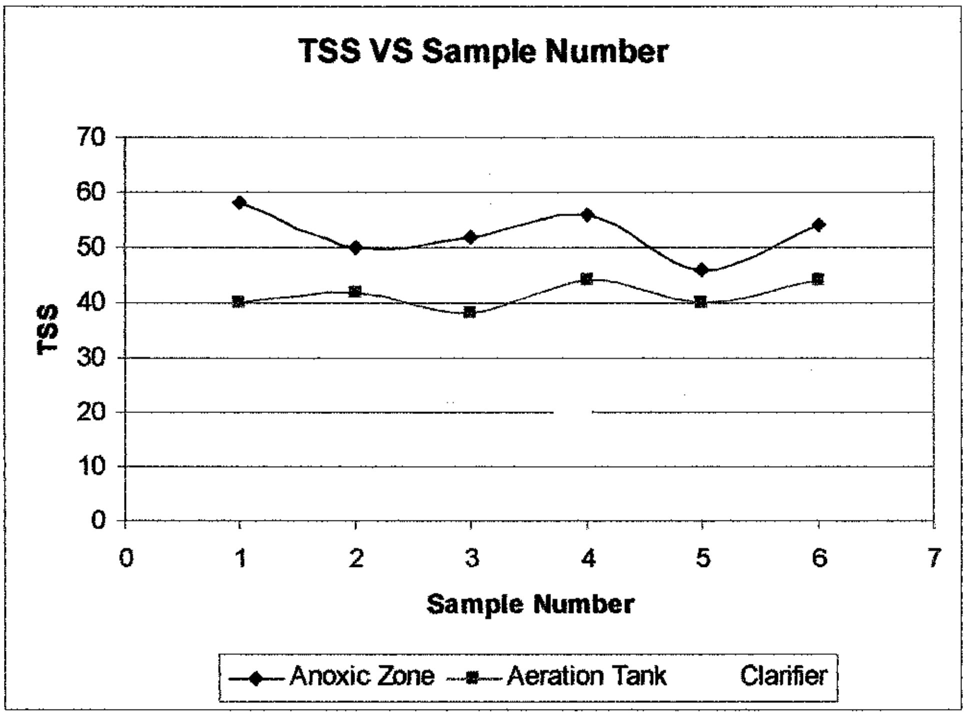
Experiment 2 (26 / 8 / 04)

ıple	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
	50	2.8417	2.8446	58	
	50	2.8486	2.8509	46	
ıder nk	50	2.8289	2.8313	48	52
	50	2.9101	2.9129	56	
	50	2.8686	2.8713	54	
	50	2.8843	2.8869	52	
	50	2.5710	2.5733	46	
	50	2.5740	2.5761	42	
ıtion nk	50	2.5720	2.5739	38	42
	25	2.5734	2.5745	44	
	25	2.5725	2.5734	36	
	25	2.5741	2.5752	44	
	50	2.5690	2.5701	22	
	50	2.5710	2.5719	18	
ifier	50	2.5680	2.5693	26	24
	25	2.5801	2.5808	28	
	25	2.5698	2.5704	24	
	25	2.5736	2.5743	28	



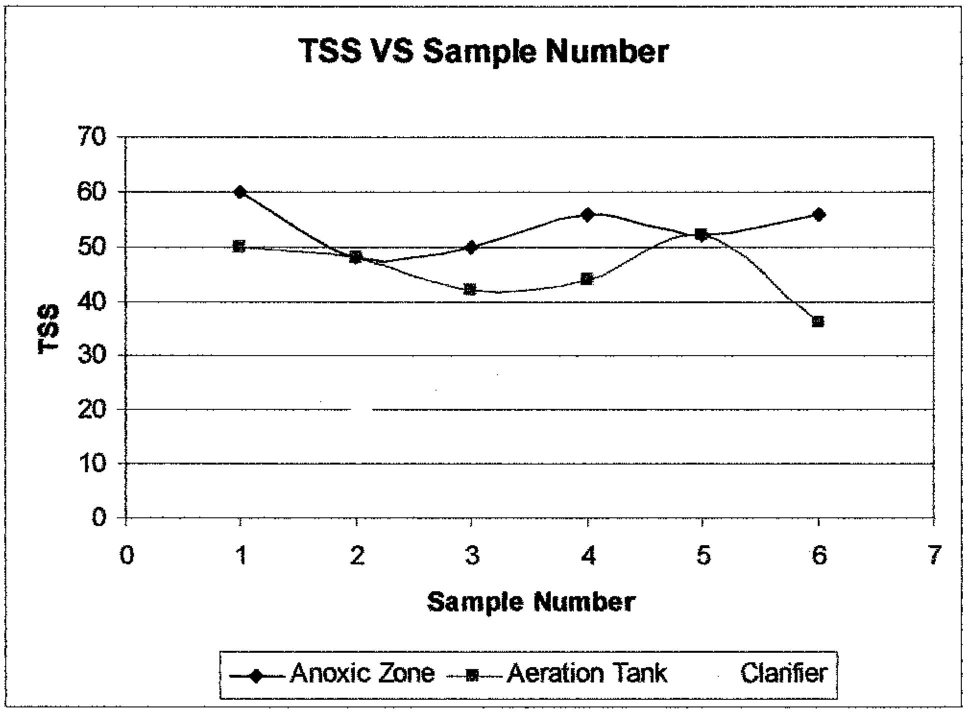
Experiment 3 (2 / 9 / 04)

ɿple	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
	50	2.8417	2.8446	58	
	50	2.8486	2.8511	50	
ɿder nk	50	2.8287	2.8313	52	53
	50	2.9200	2.9228	56	
	50	2.8688	2.8711	46	
	50	2.8843	2.8870	54	
	50	2.5660	2.5680	40	
	50	2.5730	2.5751	42	
ɿtion nk	50	2.5650	2.5669	38	41
	25	2.5653	2.5664	44	
	25	2.5667	2.5677	40	
	25	2.5691	2.5702	44	
	50	2.5710	2.5723	26	
	50	2.5680	2.5691	22	
ɿifier	50	2.5740	2.5751	22	24
	25	2.5640	2.5645	20	
	25	2.5610	2.5616	24	
	25	2.5700	2.5707	28	



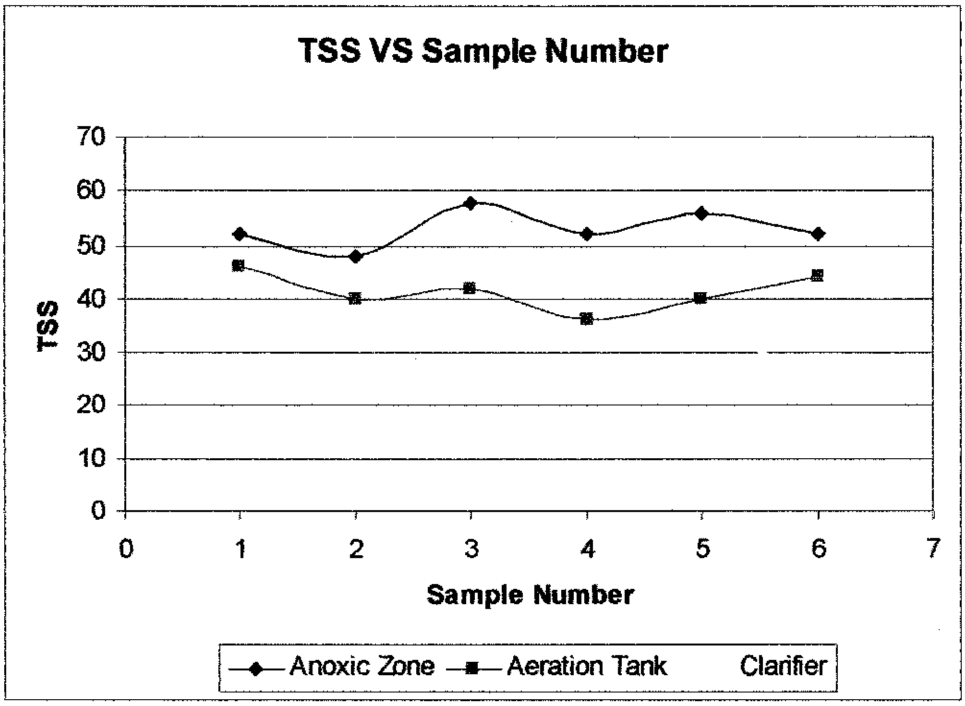
Experiment 4 (16 / 9 / 04)

ıple	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
	50	2.8861	2.8891	60	
	50	2.8689	2.8713	48	
·der	50	2.8351	2.8376	50	54
nk	25	2.9003	2.9017	56	
	25	2.8871	2.8884	52	
	25	2.8847	2.8861	56	
	50	2.5983	2.6008	50	
	50	2.5962	2.5986	48	
ıtion	50	2.6151	2.6172	42	45
nk	25	2.5388	2.5399	44	
	25	2.7716	2.7729	52	
	25	2.5862	2.5871	36	
	50	2.5386	2.5400	28	
	50	2.5129	2.5139	20	
·ifier	50	2.5278	2.5291	26	26
	25	2.5170	2.5177	28	
	25	2.5941	2.5947	24	
	25	2.5349	2.5356	28	



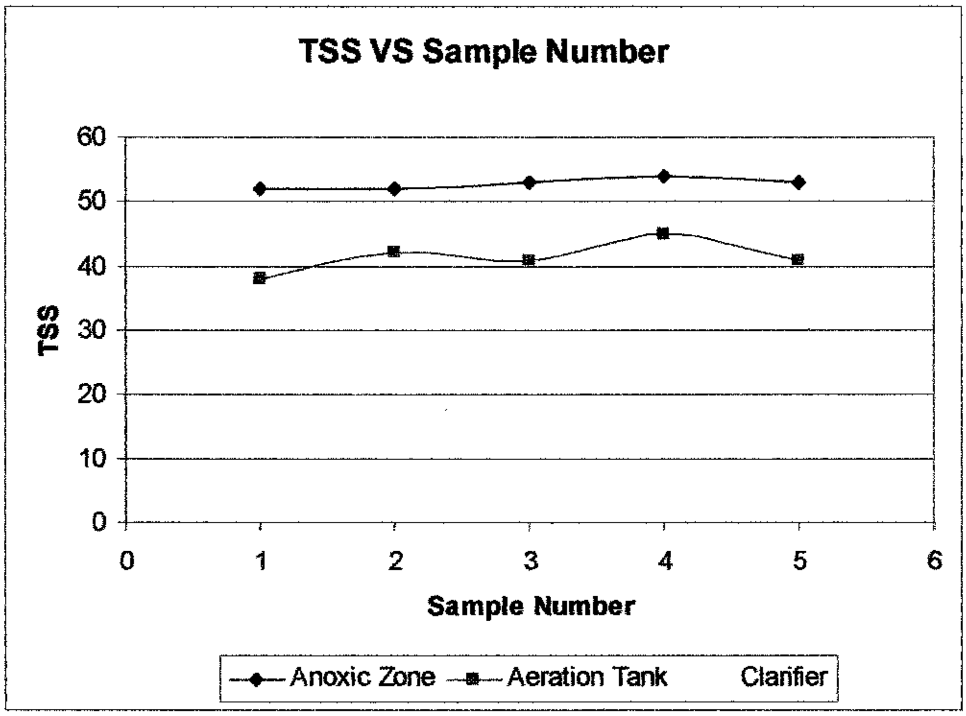
Experiment 5 (30 / 9 / 04)

nple	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
	50	2.8837	2.8863	52	
	50	2.8783	2.8807	48	
der nk	50	2.9224	2.9253	58	53
	25	2.8763	2.8776	52	
	25	2.8852	2.8866	56	
	25	2.8862	2.8875	52	
	50	2.5748	2.5771	46	
	50	2.5833	2.5853	40	
ation nk	50	2.5765	2.5786	42	41
	25	2.5622	2.5631	36	
	25	2.5417	2.5427	40	
	25	2.5921	2.5932	44	
	50	2.5689	2.5700	22	
	50	2.5745	2.5759	28	
ifier	50	2.5717	2.5731	28	27
	25	2.5612	2.5618	24	
	25	2.5651	2.5658	28	
	25	2.5565	2.5573	32	



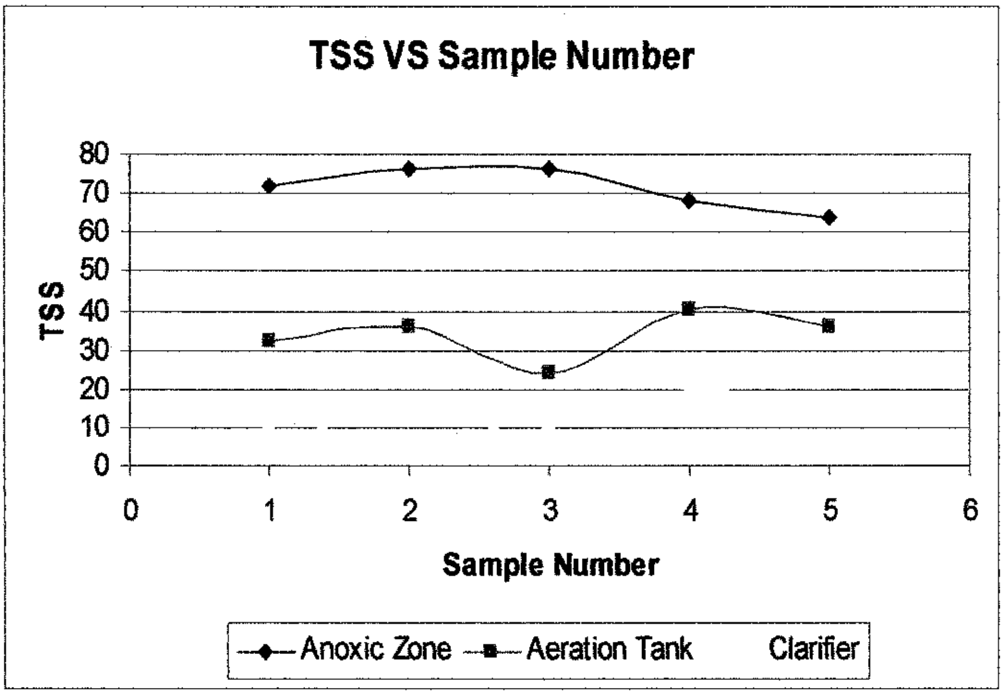
Conclusion

Sample	Experiment	TSS Results (mg/l)	Average (mg/l)
Feeder Tank	1 (12 / 8 / 04)	52	53
	2 (26 / 8 / 04)	52	
	3 (2 / 9 / 04)	53	
	4 (16 / 9 / 04)	54	
	5 (30 / 9 / 04)	53	
Aeration Tank	1 (12 / 8 / 04)	38	41
	2 (26 / 8 / 04)	42	
	3 (2 / 9 / 04)	41	
	4 (16 / 9 / 04)	45	
	5 (30 / 9 / 04)	41	
Clarifier	1 (12 / 8 / 04)	25	25
	2 (26 / 8 / 04)	24	
	3 (2 / 9 / 04)	24	
	4 (16 / 9 / 04)	26	
	5 (30 / 9 / 04)	27	



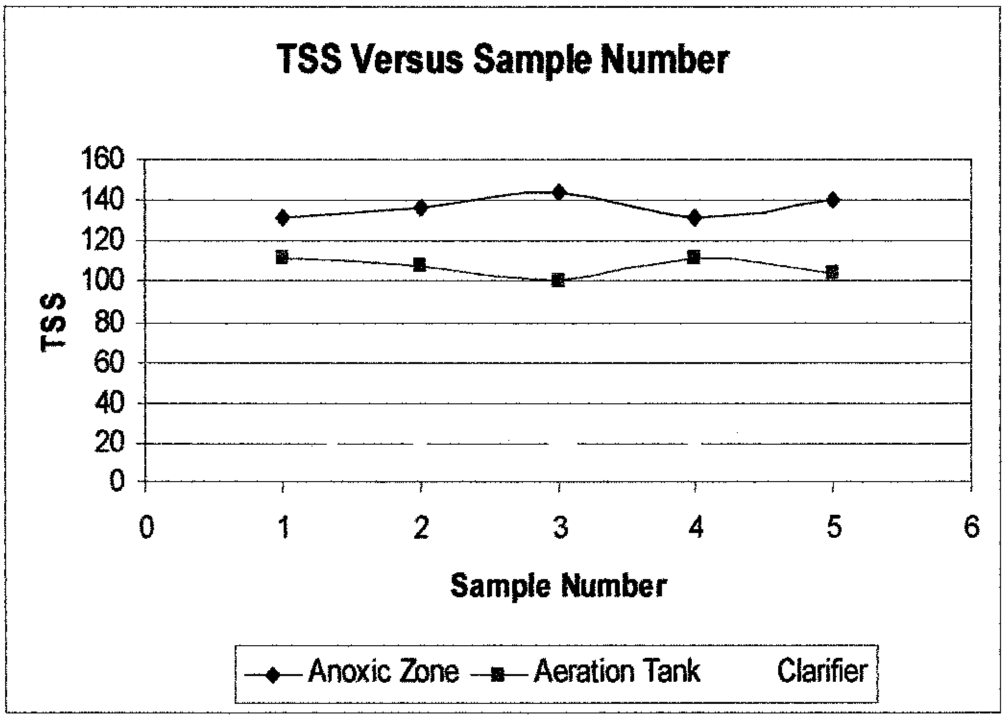
Experiment 6 (7 / 10 / 04)

Sample	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
Anoxic Zone	25	0.0838	0.0856	72	71
	25	0.0832	0.0851	76	
	25	0.0822	0.0841	76	
	25	0.0832	0.0849	68	
	25	0.0850	0.0866	64	
Aeration Tank	25	0.0823	0.0831	32	34
	25	0.0841	0.0850	36	
	25	0.0840	0.0846	24	
	25	0.0846	0.0856	40	
	25	0.0840	0.0849	36	
Clarifier	25	0.0817	0.0820	12	14
	25	0.0818	0.0820	8	
	25	0.0845	0.0848	12	
	25	0.0816	0.0821	20	
	25	0.0813	0.0817	16	



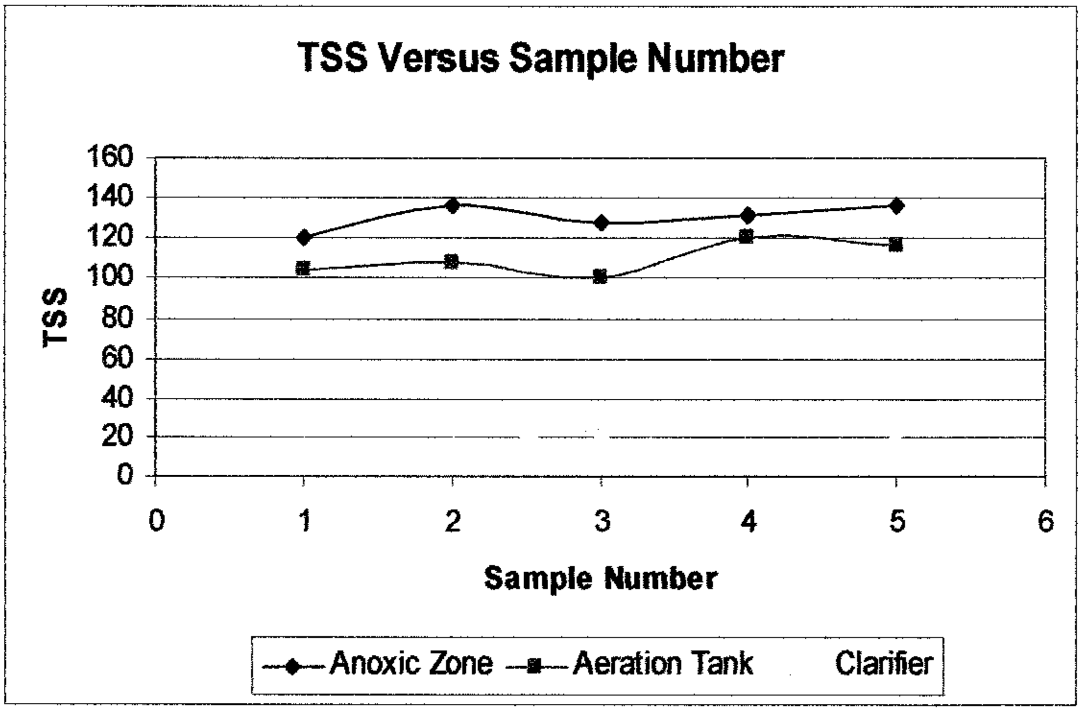
Experiment 7 (14 / 10 / 04)

Sample	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
Anoxic Zone	25	0.0843	0.0876	132	137
	25	0.0843	0.0877	136	
	25	0.0843	0.0879	144	
	25	0.0836	0.0869	132	
	25	0.0840	0.0875	140	
Aeration Tank	25	0.0836	0.0864	112	107
	25	0.0832	0.0859	108	
	25	0.0846	0.0871	100	
	25	0.0831	0.0859	112	
	25	0.0844	0.0870	104	
Clarifier	25	0.0828	0.0832	16	22
	25	0.0837	0.0843	24	
	25	0.0826	0.0831	20	
	25	0.0829	0.0835	24	
	25	0.0840	0.0847	28	



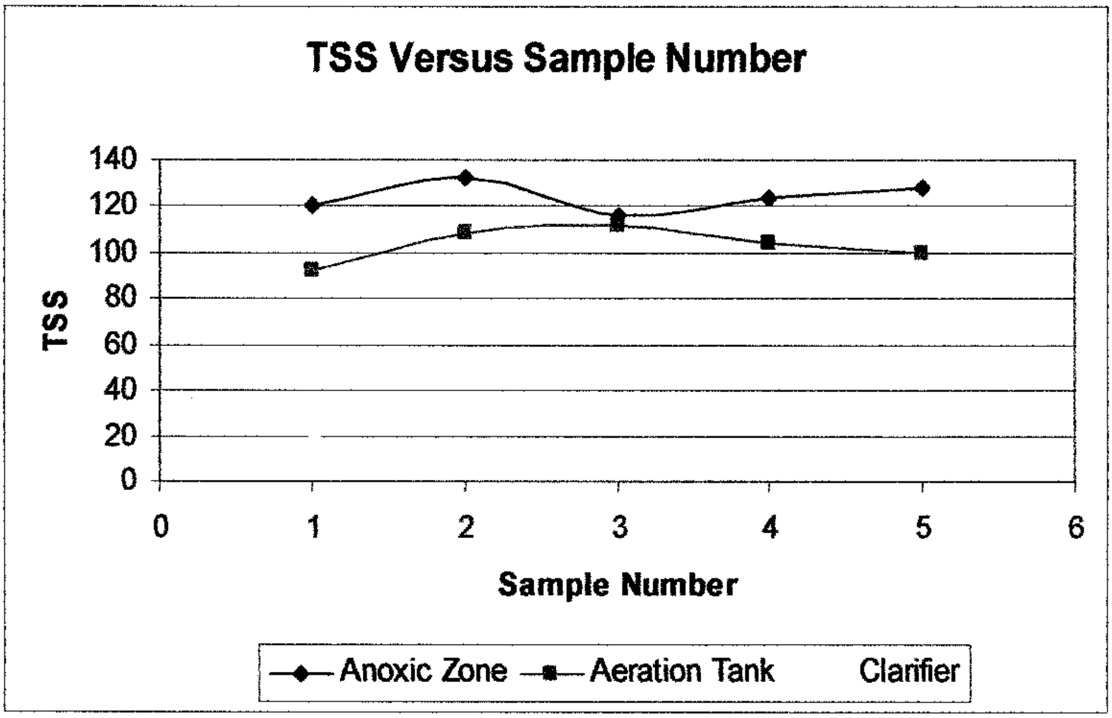
Experiment 8 (21 / 10 / 04)

ample	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
	25	0.0833	0.0863	120	
ınoxic	25	0.0822	0.0856	136	
Zone	25	0.0823	0.0855	128	130
	25	0.0817	0.0850	132	
	25	0.0831	0.0865	136	
	25	0.0829	0.0855	104	
ɘration	25	0.0803	0.0830	108	
Tank	25	0.0815	0.0840	100	110
	25	0.0834	0.0864	120	
	25	0.0827	0.0856	116	
	25	0.0843	0.0847	16	
	25	0.0829	0.0833	16	
larifier	25	0.0842	0.0848	24	21
	25	0.0817	0.0824	28	
	25	0.0837	0.0842	20	



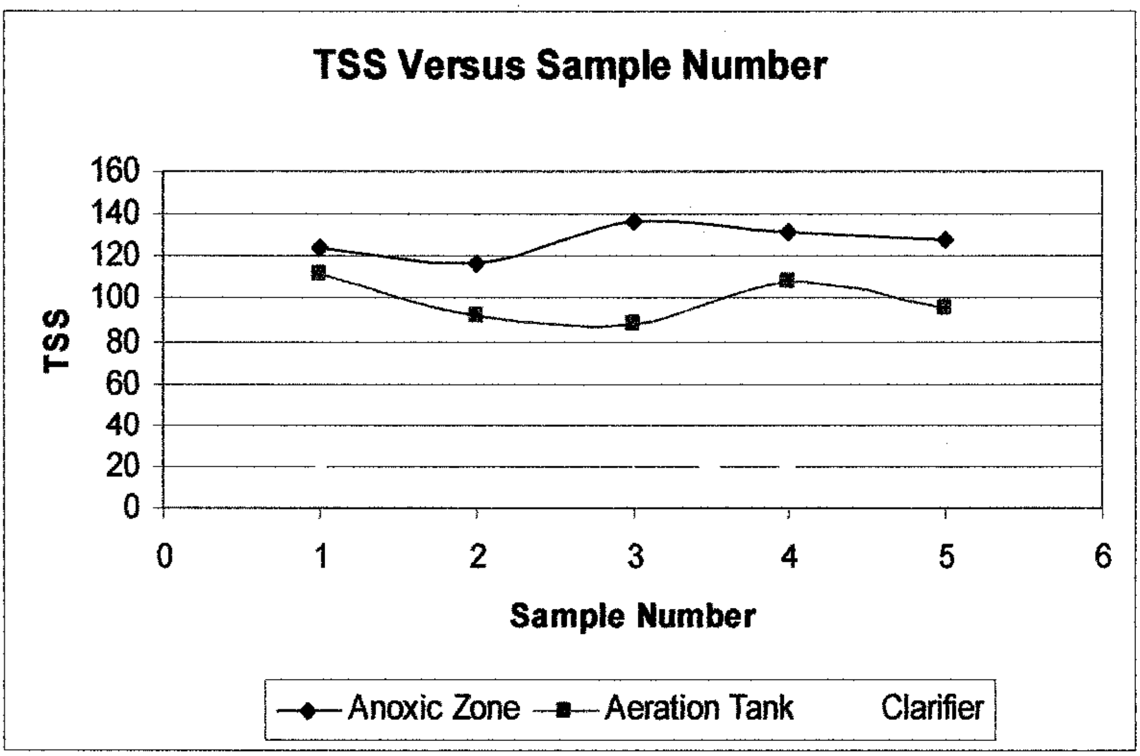
Experiment 9 (28 / 10 / 04)

ıple	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
	25	0.0836	0.0866	120	
›xic	25	0.0824	0.0857	132	
ne	25	0.0839	0.0868	116	124
	25	0.0845	0.0876	124	
	25	0.0819	0.0851	128	
	25	0.0827	0.0850	92	
ıtion	25	0.0824	0.0851	108	
nk	25	0.0818	0.0846	112	103
	25	0.0834	0.0860	104	
	25	0.0841	0.0866	100	
	25	0.0841	0.0846	20	
	25	0.0843	0.0850	28	
ifier	25	0.0826	0.0834	32	26
	25	0.0840	0.0847	28	
	25	0.0838	0.0844	24	



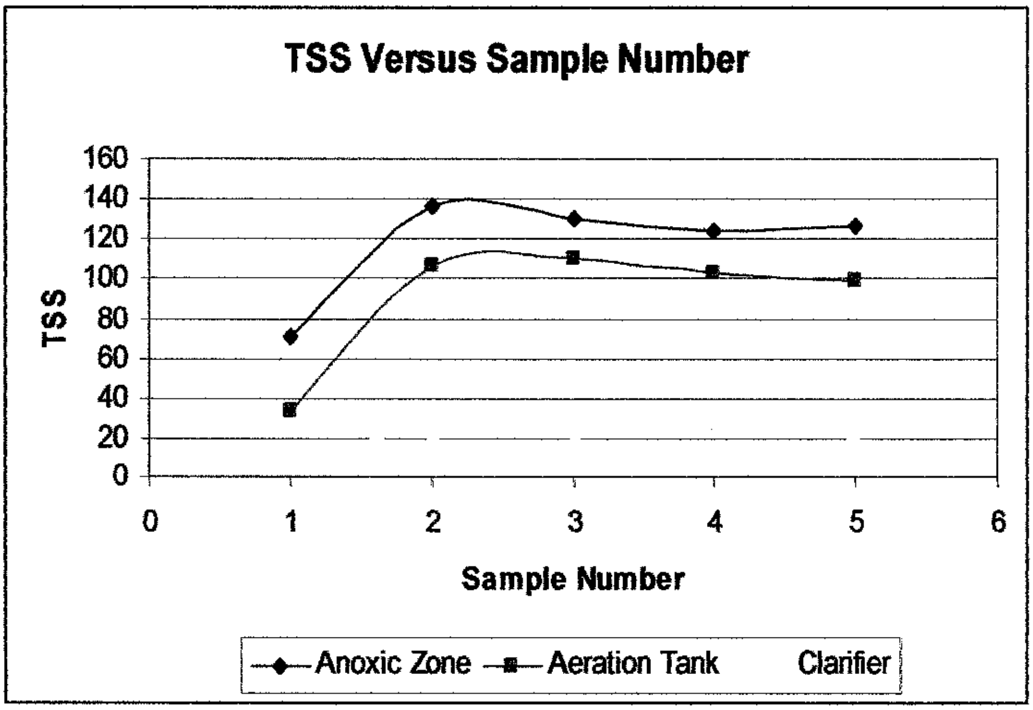
Experiment 10 (4 / 11 / 04)

ple	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
	25	0.0815	0.0846	124	
xic	25	0.0816	0.0845	116	
ne	25	0.0823	0.0857	136	127
	25	0.0819	0.0852	132	
	25	0.0821	0.0853	128	
	25	0.0835	0.0863	112	
tion	25	0.0839	0.0862	92	
nk	25	0.0841	0.0863	88	99
	25	0.0827	0.0854	108	
	25	0.0835	0.0859	96	
	25	0.0823	0.0828	20	
	25	0.0824	0.0827	12	
fier	25	0.0831	0.0835	16	20
	25	0.0837	0.0843	24	
	25	0.0827	0.0834	28	



Conclusion

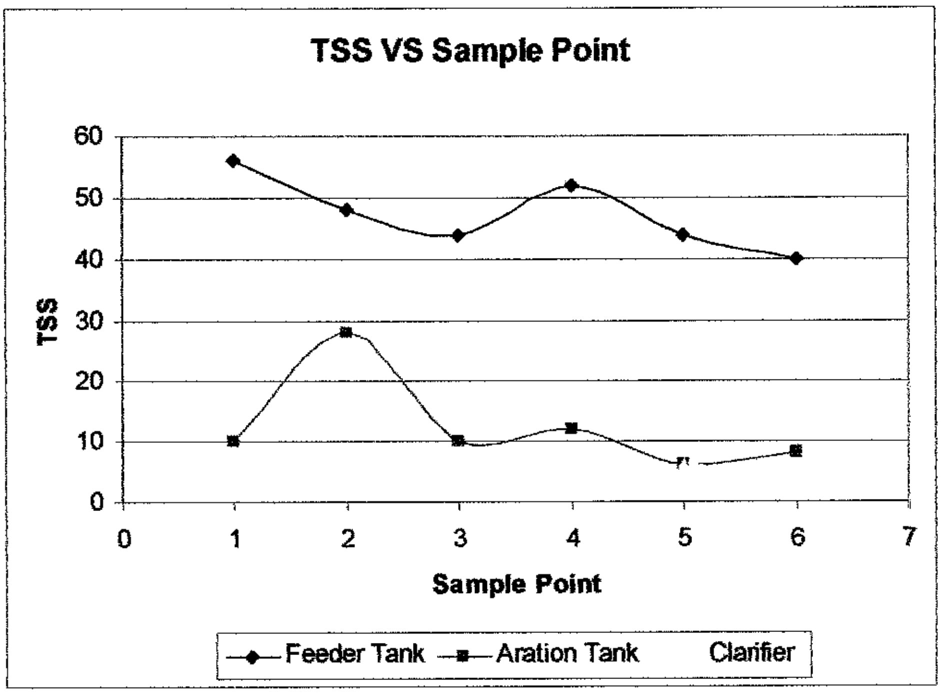
Sample	Experiment	TSS Results (mg/l)	Average (mg/l)
Anoxic Zone	6 (7 / 10 / 04)	71	130
	7 (14 / 10 / 04)	137	
	8 (21 / 10 / 04)	130	
	9 (28 / 10 / 04)	124	
	10 (4 / 11 / 04)	127	
Aeration Tank	6 (7 / 10 / 04)	34	105
	7 (14 / 10 / 04)	107	
	8 (21 / 10 / 04)	110	
	9 (28 / 10 / 04)	103	
	10 (4 / 11 / 04)	99	
Clarifier	6 (7 / 10 / 04)	14	22
	7 (14 / 10 / 04)	22	
	8 (21 / 10 / 04)	21	
	9 (28 / 10 / 04)	26	
	10 (4 / 11 / 04)	20	



PILOT PLANT RESULTS

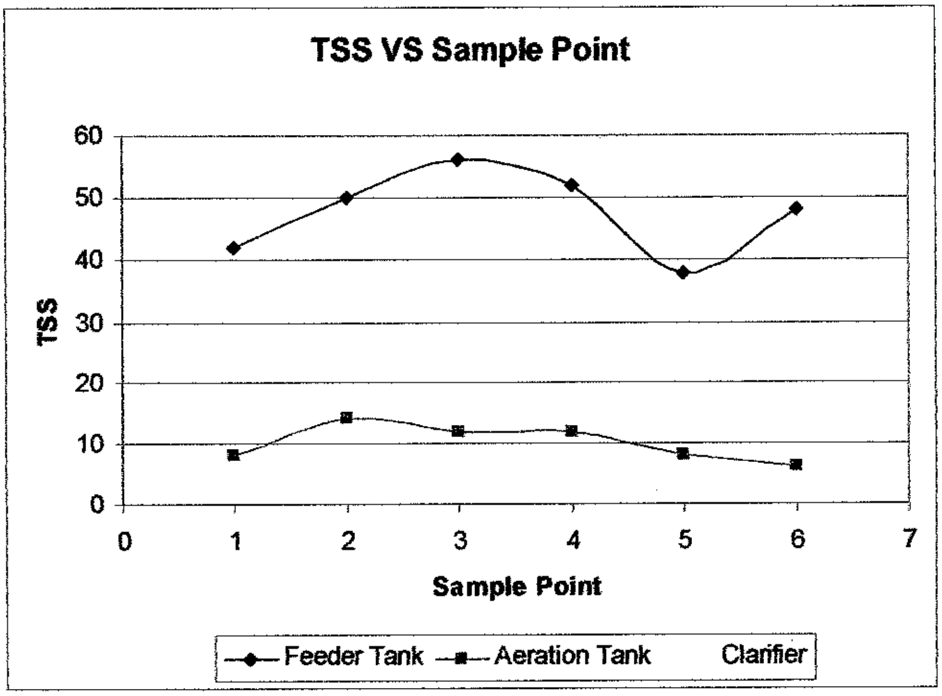
Experiment 1 (11 / 8 / 04)

ımple	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
	50	2.8857	2.8885	56	
	50	2.8781	2.8805	48	
ıeder	50	2.9219	2.9241	44	47
'ank	25	2.8752	2.8765	52	
	25	2.8823	2.8834	44	
	25	2.8851	2.8861	40	
	50	2.8688	2.8693	10	
	50	2.8615	2.8629	28	
ration	50	2.8419	2.8424	10	12
'ank	50	2.8308	2.8314	12	
	50	2.8431	2.8434	6	
	50	2.8296	2.8300	8	
	50	2.8822	2.8824	4	
	50	2.9209	2.9210	2	
arifier	50	2.8755	2.8758	6	4
	50	2.8888	2.8889	2	
	50	2.8750	2.8753	6	
	50	2.8531	2.8532	2	



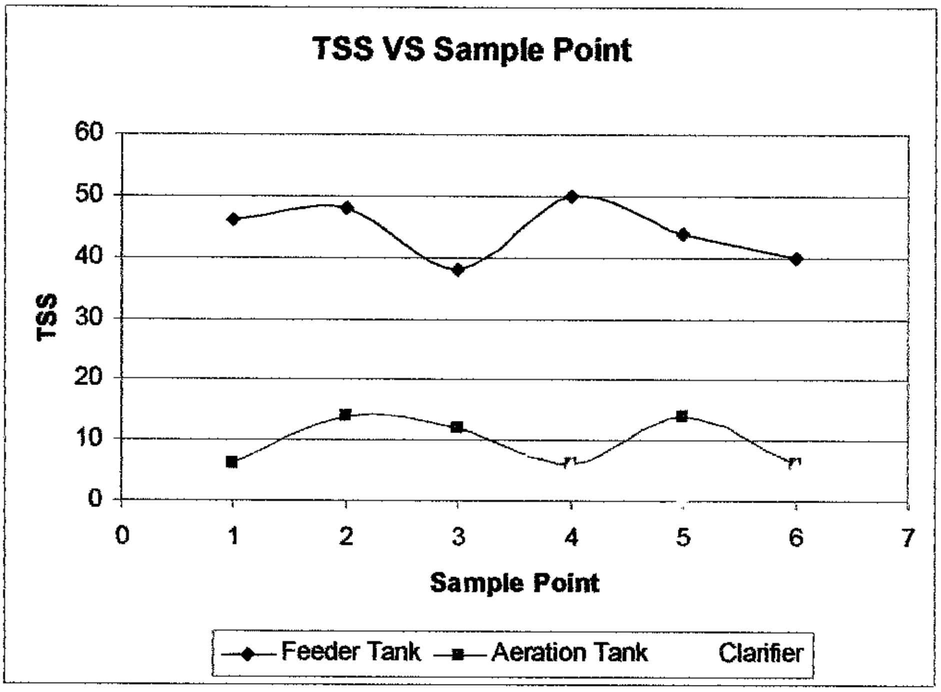
Experiment 2 (25 / 8 / 04)

ımple	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
	50	2.8425	2.8446	42	
	50	2.8588	2.8613	50	
·eder 'ank	50	2.8293	2.8321	56	48
	50	2.8996	2.9022	52	
	50	2.9003	2.9022	38	
	50	2.8838	2.8862	48	
	50	2.8421	2.8425	8	
	50	2.8819	2.8826	14	
ration 'ank	50	2.8760	2.8766	12	10
	50	2.8761	2.8767	12	
	50	2.8890	2.8894	8	
	50	2.8710	2.8713	6	
	50	2.8573	2.8574	2	
	50	2.7890	2.7893	6	
arifier	50	2.8721	2.8724	6	4
	50	2.9131	2.9133	4	
	50	2.8564	2.8565	2	
	50	2.8931	2.8933	4	



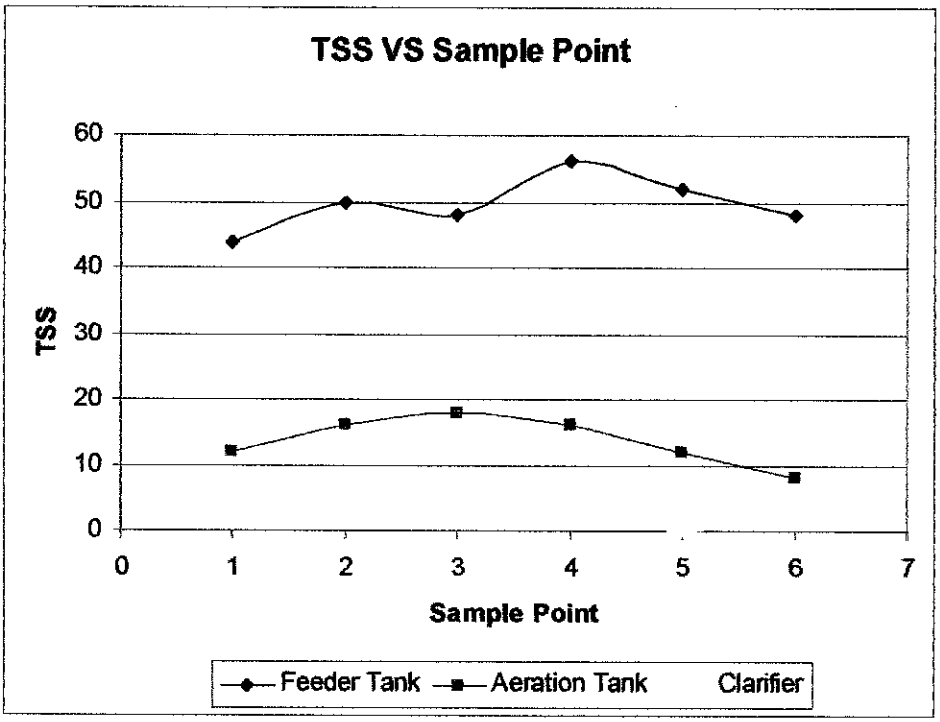
Experiment 3 (1 / 9 / 04)

mple	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
eder ank	50	2.8423	2.8446	46	44
	50	2.8486	2.8510	48	
	50	2.8257	2.8276	38	
	50	2.9201	2.9226	50	
	50	2.8679	2.8701	44	
	50	2.8856	2.8876	40	
ration ank	50	2.8421	2.8424	6	10
	50	2.8819	2.8826	14	
	50	2.8760	2.8766	12	
	50	2.8761	2.8764	6	
	50	2.8888	2.8895	14	
	50	2.8710	2.8713	6	
ırifier	50	2.8652	2.8653	2	4
	50	2.8415	2.8417	4	
	50	2.7981	2.7985	8	
	50	2.7952	2.7955	6	
	50	2.8791	2.8791	0	
	50	2.8692	2.8695	6	



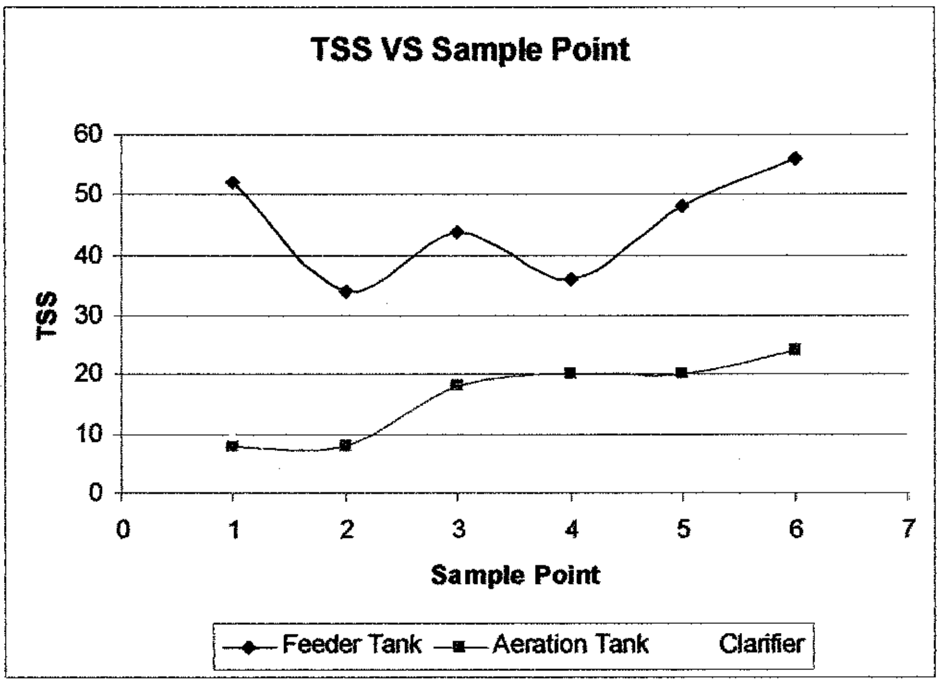
Experiment 4 (15 / 9 / 04)

mple	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
	50	2.8859	2.8881	44	
	50	2.8664	2.8689	50	
eder	50	2.8436	2.8460	48	50
ank	25	2.9000	2.9014	56	
	25	2.8794	2.8807	52	
	25	2.8851	2.8863	48	
	50	2.8235	2.8241	12	
	50	2.8189	2.8197	16	
ation	50	2.8304	2.8313	18	14
ank	25	2.8287	2.8291	16	
	25	2.8765	2.8768	12	
	25	2.8823	2.8825	8	
	50	2.8417	2.8419	4	
	50	2.8596	2.8597	2	
rifier	50	2.9121	2.9123	4	3
	25	2.8683	2.8684	4	
	25	2.8945	2.8945	0	
	25	2.8682	2.8683	4	



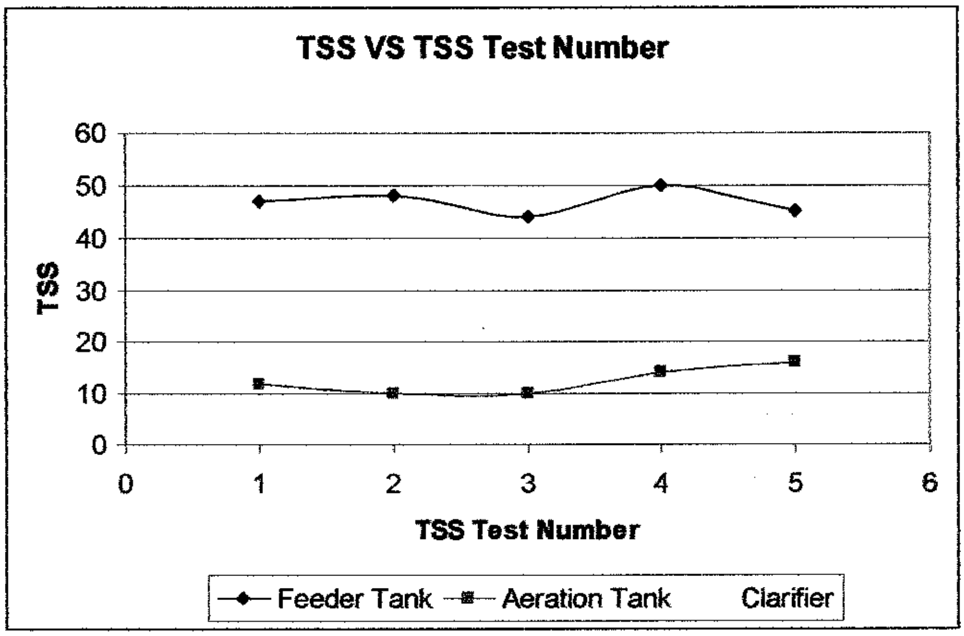
Experiment 5 (29 / 9 / 04)

mple	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
eeder ank	50	2.8841	2.8867	52	45
	50	2.8755	2.8772	34	
	50	2.9226	2.9248	44	
	25	2.8782	2.8791	36	
	25	2.8854	2.8866	48	
	25	2.8862	2.8876	56	
ration ank	50	2.8636	2.8640	8	16
	50	2.8706	2.8710	8	
	50	2.8171	2.8180	18	
	25	2.8149	2.8154	20	
	25	2.8285	2.8290	20	
	25	2.8399	2.8405	24	
arifier	50	2.8849	2.8854	10	7
	50	2.8328	2.8329	2	
	50	2.8544	2.8548	8	
	25	2.8651	2.8653	8	
	25	2.9085	2.9086	4	
	25	2.8758	2.8760	8	



Conclusion

Sample	TSS Test Number	TSS Results (mg/l)	Average (mg/l)
Feeder Tank	1 (11 / 8 / 04)	47	47
	2 (25 / 8 / 04)	48	
	3 (1 / 9 / 04)	44	
	4 (15 / 9 / 04)	50	
	5 (29 / 9 / 04)	45	
Aeration Tank	1 (11 / 8 / 04)	12	12
	2 (25 / 8 / 04)	10	
	3 (1 / 9 / 04)	10	
	4 (15 / 9 / 04)	14	
	5 (29 / 9 / 04)	16	
Clarifier	1 (11 / 8 / 04)	4	4
	2 (25 / 8 / 04)	4	
	3 (1 / 9 / 04)	3	
	4 (15 / 9 / 04)	3	
	5 (29 / 9 / 04)	7	



Experiment 6 (8 / 10 / 04)

Sample	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
Feeder Tank	25	2.8322	2.8333	44	50
	25	2.8633	2.8645	48	
	25	2.9103	2.9117	56	
	25	2.8790	2.8802	48	
	25	2.8539	2.8552	52	
Aeration Tank	25	2.8893	2.8928	14000	11920
	25	2.8776	2.8802	10400	
	25	2.8297	2.8325	11200	
	25	2.8428	2.8459	12400	
	25	2.8654	2.8683	11600	
Clarifier	25	2.857	2.8573	12	14
	25	2.8300	2.8304	16	
	25	2.8722	2.8724	8	
	25	2.8375	2.8379	16	
	25	2.8351	2.8356	20	

Experiment 7 (13 / 10 / 04)

Sample	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
Feeder Tank	25	2.8644	2.8655	44	47
	25	2.8219	2.8231	48	
	25	2.8186	2.8196	40	
	25	2.8883	2.8897	56	
	25	2.8791	2.8803	48	
Aeration Tank	25	2.8756	2.8764	3200	3200
	25	2.8570	2.8576	2400	
	25	2.8324	2.8333	3600	
	25	2.8321	2.8328	2800	
	25	2.8654	2.8664	4000	
Clarifier	25	2.8359	2.8361	8	15
	25	2.8132	2.8135	12	
	25	2.8725	2.8730	20	
	25	2.8284	2.8287	12	
	25	2.8625	2.8631	24	

Experiment 8 (20 / 10 / 04)

ample	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
	25	2.8375	2.8384	36	
eeder	25	2.8149	2.8161	47	
Tank	25	2.8339	2.8350	43	40
	25	2.8300	2.8308	32	
	25	2.8639	2.8649	40	
	25	2.8649	2.8656	2800	
	25	2.8223	2.8231	3200	
eration	25	2.8188	2.8194	2400	2960
Tank	25	2.8887	2.8894	2800	
	25	2.9101	2.9110	3600	
	25	2.8586	2.8592	24	
	25	2.8319	2.8324	20	
larifier	25	2.8737	2.8744	28	26
	25	2.8393	2.8401	32	
	25	2.8467	2.8473	24	

Experiment 9 (27 / 10 / 04)

ample	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
	25	2.8342	2.8352	40	
eeder	25	2.8655	2.86635	34	
ank	25	2.9124	2.9131	28	36
	25	2.8809	2.882	44	
	25	2.8635	2.8643	32	
	25	2.8641	2.8648	2800	
	25	2.8763	2.8771	3200	
ration	25	2.8429	2.8435	2400	2880
ank	25	2.8897	2.8905	3200	
	25	2.8120	2.8127	2800	
	25	2.8671	2.8677	24	
	25	2.8357	2.8362	20	
arifier	25	2.8460	2.8463	12	20
	25	2.8769	2.8773	16	
	25	2.9132	2.9139	28	

Experiment 10 (3 / 11 / 04)

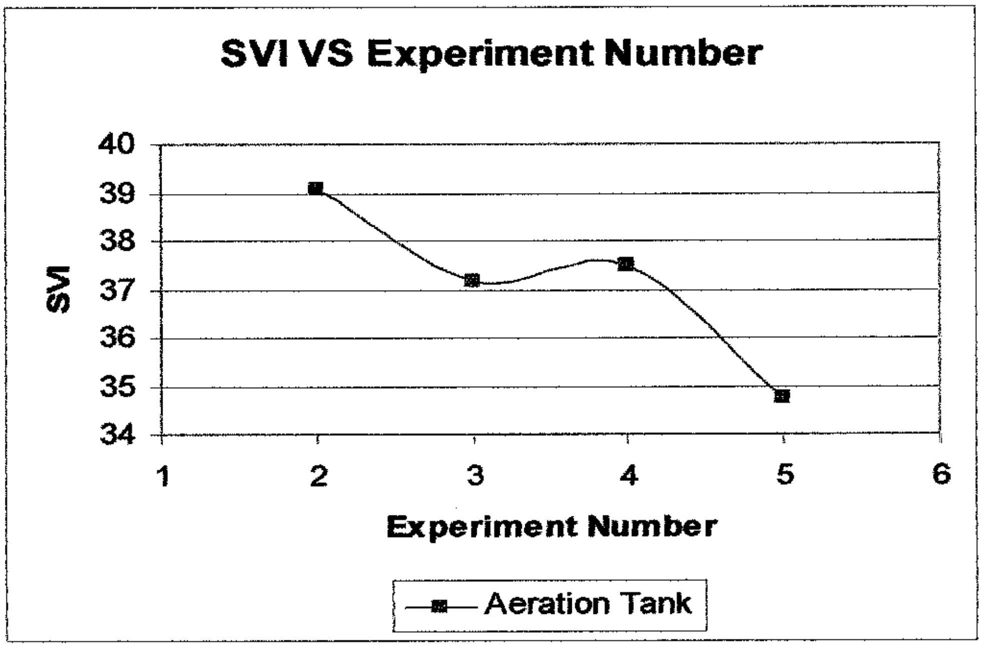
ample	Volume of sample (ml)	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
	25	2.8468	2.8478	40	
eeder	25	2.8367	2.8375	32	
Tank	25	2.9312	2.9321	36	32
	25	2.8742	2.8748	24	
	25	2.8965	2.8972	28	
	25	2.8156	2.8162	2400	
	25	2.8742	2.8747	2000	
eration	25	2.8246	2.8253	2800	2160
Tank	25	2.8356	2.8360	1600	
	25	2.8128	2.8133	2000	
	25	2.8462	2.8467	20	
	25	2.8672	2.8679	27	
larifier	25	2.8795	2.8801	24	24
	25	2.8269	2.8275	24	
	25	2.8354	2.8361	26	

Conclusion

Sample	TSS Test Number	TSS Results (mg/l)	Average (mg/l)
Feeder Tank	6 (8 / 10 / 04)	50	41
	7 (13 / 10 / 04)	47	
	8 (20 / 10 / 04)	40	
	9 (27 / 10 / 04)	36	
	10 (3 / 11 / 04)	32	
Aeration Tank	6 (8 / 10 / 04)	11920	2800
	7 (13 / 10 / 04)	3200	
	8 (20 / 10 / 04)	2960	
	9 (27 / 10 / 04)	2880	
	10 (3 / 11 / 04)	2160	
Clarifier	6 (8 / 10 / 04)	14	20
	7 (13 / 10 / 04)	15	
	8 (20 / 10 / 04)	26	
	9 (27 / 10 / 04)	20	
	10 (3 / 11 / 04)	24	

SVI RESULTS

Sample	SVI Test Number	Sludge Settleability (ml/l)	SVI Result (ml/g)
Aeration Tank	1 (8 / 10 / 04)	-	-
	2 (13 / 10 / 04)	125	39
	3 (20 / 10 / 04)	110	37
	4 (27 / 10 / 04)	108	38
	5 (3 / 11 / 04)	75	35



MLSS CALCULATION

Since 25 ml of oxidation pond sludge result in 11,920 mg/l of suspended solids, we want to reduce the suspended solids concentration to 3,000 mg/l (which is STP design criteria).

Step 1: **Assume that, 11,920 mg/l ≈ 12,000 mg/l**

Step 2: **Identify how much concentration of suspended solids need to be discharge**

Given; volume of pilot plant aeration tank = 300 liter
(12000 mg/l) X (300 l) = 3600000 mg of suspended solids
(3000 mg/l) X (300 l) = 900000 mg of desired suspended solids
Thus, (3600000 mg of suspended solids) – (900000 mg of desired suspended solids) = (2700000 mg of suspended solids to be waste)

Step 3: **Identify how much volume of Mixed Liquor Suspended Solids (MLSS) need to be discharge**

(2700000 mg) / (12000 mg/l) = 225 liter of Mixed Liquor Suspended Solids (MLSS) need to be discharge