EVALUATION THE PERFORMANCE OF VARIOUS PARAMETERS USED TO CHARACTERIZE WASTEWATER FOR UTP SEWAGE TREATMENT PLANT & UTP OXIDATION POND

by

NORAZHAM BIN AZMI

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Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Approved by,

(Dr. Shamsul Rahman)

UNIVERSITI TEKNOLOGI PETRONAS

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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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Norazham Bin Azmi

ABSTRACT

This report is a study for evaluation the performance of various parameters used to characterize wastewater for UTP Sewage Treatment Plant and UTP oxidation pond.

University Technology Petronas Sewage Treatment Plant (UTP's STP) is a treatment plant that used an Extended Aeration Activated Sludge (EEAS). The sewage treatment plant is capable to treat effluent to a standard A which is 20mg/l of BOD and 50mg/l of suspended solids. 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 were condered for design. The design basis flow rate for this plant is about 5,175.00 m^3/d or 23,000 population equivalent. This sewage treatment plant consists of inlet chamber, grit and grease chamber, distribution chamber, anoxic zone, aeration tank, clarifier and chlorination tank.

UTP oxidation pond was designed to support 2000 populations from UTP and classified as a facultative pond which the stabilization of wastewater is done by a combination of aerobic, anaerobic and facultative bacteria. The influent of wastewater that enters to the pond is assumed consisted of 250 mg/l BOD and 300 mg/l of total suspended solids (TSS). The treated effluent for this oxidation pond should meet the standard A limit which is 20 mg/l of BOD and 50 mg/l of total suspended solid. This UTP oxidation pond contains a rubbish trap chamber, parshall flume chamber, scum chamber, oxidation pond and settling pond.

At the beginning stage, the problems are identified on the various parameters such like biochemical oxygen demand (BOD) and total suspended solids (TSS). Samples from UTP's STP and oxidation pond was taken and identified frequently to analyze the wastewater in the laboratory. The sample was taken by using grab and composite sampling method at the influent and effluent of the UTP's STP and UTP oxidation pond.

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INTRODUCTION

1.1 Characteristics of wastewater

An understanding of the nature of wastewaters is essential in the design and operation of treatment and disposal facilities in the engineering management of environmental quality. A methodology employing historical (happenstance) data from a wastewater treatment plant involving several daily average reported variables (such as BOD, TSS, DO, Detention Time, Air, and Sludge Age) over a period of a year is utilized to predict effluent water quality. [Jamie Bartram]

Wastewater is characterized in terms of its physical, chemical and biological composition. The physical properties of wastewater are such like the colour, odour, temperature and solids at the plant. These physical properties are the main factors that affect both chemical and biologically activity in the wastewater. [Jamie Bartram]

In the wastewater treatment plant, about 75% of the suspended solids and 40% of the filterable solids are organic in nature. These organic compounds are normally composed of a combination of carbon, hydrogen, oxygen, nitrogen and together with other important elements such as sulphur, phosphorus and iron. [Qasim]

Over the years, a number of different tests have been developed to determine the organic content of wastewaters. In general, the tests may be divided into those used to measure gross concentrations of organic matter greater than about 1 mg/L and those used to measure trace concentrations in the range of 10^{-12} to 10^{-3} mg/L. Laboratory tests commonly used today to measure gross amounts of organic matter in wastewater such like Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Organic Carbon (TOC) and Total Suspended Solids (TSS). [Metcalf & Eddy]

1.2 Problem Statement

This project is to evaluate the performance of various parameters at influent and effluent of the University Technology Petronas Sewage Treatment Plant (UTP's STP) and UTP Oxidation Pond.

1.3 Objective of Study

The main objectives of the project are:

I. To study of TSS at the influent and effluent of UTP's STP and UTP Oxidation Pond.
II. To study of BOD at the influent and effluent of UTP's STP and UTP Oxidation Pond.
III. To study of TSS and BOD removal at the influent and effluent of UTP's STP and UTP Oxidation Pond.

1.4 Scope of Study

I. To conduct laboratory works (grab sampling method) on total suspended solids (TSS) and biochemical oxygen demand (BOD) at influent and effluent of the UTP's STP and UTP Oxidation Pond.
II. To conduct a composite sampling method for 24 hours on total suspended solids (TSS) and biochemical oxygen demand (BOD) at influent of UTP's STP during weekdays and weekends.

CHAPTER 2

LITERATURE REVIEW

2.1 Background of Study

2.1.1 Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand (BOD) represents the amount of oxygen required to stabilize the organic matter by microorganisms under aerobic condition. The most widely used parameter of organic pollution applied to wastewater is the 5-day BOD (BOD_5). [Metcalf & Eddy]

The incubation period for BOD_5 is usually conducted for five days at 20°C, but other length and temperatures can be used. The temperature however, should be constant throughout the test. Biochemical oxidation is a slow process and theoretically takes an infinite time to go to completion. The temperature (20°C) is used an average value for slow-moving streams in temperate climates and different results would be obtained at different temperatures because biochemical reaction rates are temperature-dependent [Jamie Bartram].

The most important of BOD_5 test is to determine the approximate quantity of oxygen that will be required to biologically stabilize the organic matter present. Beside that, this BOD_5 also is used to determine the size of wastewater treatment facilities and to measure the efficiency of some treatment processes. This BOD_5 also is important to determine compliance with wastewater discharge permits [Metcalf & Eddy].

A portion of the waste is oxidized to end products to obtain energy for cell maintenance and synthesis of new cell tissue. Simultaneously, some of the 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. Using the terms COHNS (which represents the elements carbon, oxygen, hydrogen, nitrogen and sulfur) to represent the organic waste and the term $C_5H_7NO_2$ (fist proposed by Hoover and Porges (1952)) to represents tissue.

The processes are defines by the following generalized chemical reactions:

Oxidations

COHNS + O_2 + bacteria → CO_2 + H_2O + NH_3 + other end products + energy

Synthesis

COHNS + O_2 + bacteria +energy → $C_5H_7NO_2$ (new cell tissue)

Endogenous respiration

$C_5H_7NO_2 + 5O_2 \rightarrow 5CO_2 + NH_3 + 2H_2O$

If only the oxidation of the organic carbon that is present in the waste is considered, the ultimate BOD is the oxygen required to complete the three reactions given above. This oxygen demand is known as the ultimate carbonaceous BOD and usually denoted as UBOD [Metcalf & Eddy].

To ensure that meaningful results are obtained, the sample must be suitably diluted with specially prepared dilution water so that adequate nutrients and oxygen will be available during the incubation period. After the bottle is incubated for 5 days at 20^0C, the dissolved oxygen concentration is measured again. The BOD of the sample is the difference in the dissolved oxygen concentration values, expressed in milligrams per liter divided by the decimal fraction of sample used. The computed BOD value is known as the 5-day, 20^0C biochemical oxygen demand. [Qasim]

Biochemical oxygen demand (BOD) also is the most commonly used parameter to define the strength of a municipal or organic industrial wastewater. Its widest application is in measuring waste loadings to treatment plants in evaluating the efficiency of such treatment systems. In addition, BOD test is used to determine the relative oxygen requirement to treated effluent and polluted waters. However, it is of limited value in measuring the actual oxygen demand of surface waters and extrapolation of test results to actual stream oxygen demands since the laboratory environment cannot reproduce the physical, chemical and biological stream conditions. [Mark J. Hammer].

BOD is by definition the quantity of oxygen utilized by a mixed population of microorganisms in the aerobic oxidation (of the organic matter in sample of wastewater) at a temperature of 20°C in an air incubator or water bath. A plastic cup or foil cap is placed over the flared mouth of the BOD bottle during incubation to reduce evaporation of the water seal. Measured amounts of wastewater diluted with distilled water are placed in 300 ml BOD bottles. The dilution water containing phosphate buffer, magnesium sulfate, calcium chloride and ferric chloride is saturated with dissolved oxygen. Seed microorganisms are supplied to oxidize the waste organics if sufficient microorganisms are not already present in the wastewater sample. The general biological reaction that takes place is shown below: [Mark J. Hammer].

Organic Matter → CO_2 + Bacterial Cells → CO_2 + Protozoal Cells

The wastewater supplies the organic matter (biological food) and the dilution water furnishes the dissolved oxygen. The primary reaction metabolism of the organic matter and uptake of dissolved oxygen by bacteria releasing carbon dioxide and producing substantial increase in bacterial population. The secondary reaction results from the oxygen used by the protozoa-consuming bacteria, a predator-prey reaction. Depletion of dissolved oxygen in the test bottle is directly related to the amounts of degradable organic matter. [Sawyer McCarty]

The biochemical oxygen demand of a wastewater is a time dependent. Carbonaceous oxygen demand progresses at a decreasing rate with time since the rate of biological activity decreased as the available food supply diminishes. Nitrifying bacteria can exert oxygen in the BOD test as shown below:

NH_3 + Oxygen → NO^{-2} + Energy

Fortunately, the growth of nitrifying bacteria lags behind that of the microorganisms performing the carbonaceous reaction. Nitrification generally does not occur until several days after the standard five-day incubation period for BOD tests on untreated wastewaters. Treatment plant effluents and stream waters may show early nitrification where the sample has a relatively high population of nitrifying bacteria. Tests on real wastewater normally show observations varying from 10 to 20 percent on either side of the mean. The larger variations occur in testing wastewaters that require seeding or contain substances that inhibit biological activity and treatment plat effluent samples that are affected by nitrification. [Mark J. Hammer]

When testing wastewaters with low concentrations of microorganisms, a seeded BOD test is conducted. The organisms contained in the effluent from primary sedimentation facilities are used commonly as the seed for the BOD test. Seed organisms can also be obtained commercially. When the sample contains a large population of microorganisms (untreated wastewater), seeding is not necessary [Metcalf & Eddy].

Contaminated dilution water and dirty incubation bottles can distort BOD test results. Standard methods emphasize proper cleaning of the bottles and analysis of dilution water blanks during BOD testing as a check on the quality unseeded dilution water. The dissolved oxygen (DO) uptake for unseeded dilution water with phosphate buffer and inorganic nutrient solutions added should not be more than 0.2 mg/l and preferably not more than 0.1 mg/l after five days incubation at 20°C. [Mark J. Hammer]

No uniform relationship exists between the COD and BOD of wastewaters except that the COD value must be greater than the BOD. This is because chemical oxidation decomposes nonbiodegradable organic matter and the standard BOD test measures only the oxygen used in metabolizing the organic matter for five days. The correlation of COD to BOD for a particular wastewater can be determined by statistical comparison of several laboratory analyses. Unfortunately, such a relationship may be invalidated by the simple day-to-day variations in quality of a municipal wastewater. Occasionally, out of the necessity for converting oxygen demand data even if the results are of questionable accuracy, the COD of a soluble wastewater is assumed to be equal to the ultimate BOD. [Mark J. Hammer].

2.1.2 Total Suspended Solids (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 1.5μm. The typical total suspended solids concentration in the municipal wastewater is 230 mg/L. Total suspended solids when discharged into the natural waters 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 at the bottom progressively decompose using up dissolved oxygen and produce noxious gases [Qasim].

TSS test results are used routinely to assess the performance of conventional treatment processes and the need for effluent filtration in reuse applications. TSS test is totally depending on the pore size of the used filter paper. Filters with nominal pore sizes varying from 0.45 μm to about 2.0 μm have been used for the TSS test. More TSS will be measured as the pore size of the filter used is reduced. Thus, it is important to note the pore size of the filter paper used when comparing reported TSS values. [Metcalf & Eddy]

The terms suspended solids and dissolved solids refer to matter that is retained and passed through a standard glass-fiber filter respectively. A measured portion of sample is drawn through a glass fiber filter retained in a funnel by applying a vacuum to the suction flask. After filtration, the disk is removed from funnel, dried and weighted to determine the increase as a result of the residue retained. Dissolved matter (nonfilterable residue) is not determined directly but is calculated by subtracting suspended solids concentration [Mark J. Hammer].

The measured values of TSS are dependent on the type and pore size of the filter paper used in the analysis. Secondly, it depends on the sample size used for the determination of TSS, autofiltration where the suspended solids that have been intercepted by the filter also serve as filter can occur. Autofiltration will cause an apparent increase in the measured TSS value over the actual value. Third, depending on the characteristics of the particulate matter, small particles may be removed by adsorption to material ready retained by the filter. Fourth, TSS is a lumped parameter because the number and size distribution of the particles that comprise the measured value is unknown. [Mark J. Hammer]

Nevertheless, TSS test results are used routinely to assess the performance of conventional treatment processes and the need for effluent filtration in reuse applications. Finally, TSS is one of the two universally used effluent standards (along with BOD) by which the performance of treatment plants is judged for regulatory control purposes. [Metcalf & Eddy]

Total solids, total residue on evaporation is the term applied to material left in a dish after evaporation of a sample of wastewater and subsequent drying in an oven. A measured volume of sample is placed in an evaporating dish usually porcelain. Water is evaporated from the dish on a stream bath or in a drying oven at approximately 2°C below boiling to prevent splattering. The evaporated sample is dried for at least 1 hr in an oven at 103°C to 105°C and cooled in a desiccator to a constant weight. The milligrams of total residue are equal to the difference between the cooled weight of the dish and the original weight of the empty dish. [Qasim]

Volatile solids are determined by igniting the residue on evaporation or filtered solids at 500°C in an electric muffle furnace. Dried solids are burned for 15 to 20 minutes. Loss of weight on ignition is reported as milligrams per liter of volatile solids and residue after burning is referred to as fixed solids or ash. Volatile solids in wastewater are often interpreted as being measure of biodegradable organic matter. However, this is not precisely true since combustion of many pure organic compounds leaves an ash and many inorganic salts volatilize during ignition. [Mark J. Hammer]

2.2 Biological Treatment Systems

Biological processing is the most efficient way of removing organic matter from municipal wastewaters. These living systems rely on mixed microbial cultures to decompose and remove colloidal and dissolved organic substances from solution. The treatment chamber holding the microorganism provides controlled environment; for example, activated sludge is supplied with sufficient oxygen to maintain an aerobic condition. Wastewater contains the biological food, growth nutrients and inoculums of microorganism. [Mark J. Hammer]

Persons who are not familiar with wastewater operations often ask where the "special" biological cultures are obtained. The answer is that the wide variety of bacteria and protozoa present in domestic wastes seeds the treatment units. Then by careful control of wastewater flows, recirculation of settled microorganisms, oxygen supply and other factors, the desirable biological cultures are generated and retained the process the pollutants. The slime layer on the surface of the media in a trickling filter is developed by spreading wastewater over the bed. Within a few weeks the filter is operational, removing organic matter from liquid trickling through the bed. [Mark J. Hammer].

Activated sludge in a mechanical or diffused air system is started by turning on the aerators and feeding the wastewater. Initially a high rate of recirculation from the bottom of the final clarifier is necessary to retain sufficient biological culture. However, within a short period of time settleable biological floc matures that efficiently flocculates the waste organics. An anaerobic digester is most difficult treatment unit to start up since the methane-forming bacteria essential to digestion are not abundant in raw wastewater. Furthermore, these anaerobes grow very slowly and require optimum environmental conditions. Start up of an anaerobic digester can be hastened considerably by filling the tank with wastewater and seeding with a substantial quantity of digesting sludge from a nearby treatment plant. Raw sludge is then fed at a reduced initial rate and lime is supplied as necessary to hold pH. Even under these conditions, several months may be required to get the process fully operational. [Crites and Tchobanoglous].

Enzymes are organic catalysts that perform biochemical reactions at temperatures and chemical conditions compatible with biological life. Most enzymes cannot be isolated from living organisms without impairing their functioning capability. Enzymes for wastewater (or for anaerobic digestion, stabilization ponds and septic tanks) minimum of 10 billion colonies per gram, excellent diastic, proteolytic, amylolytic and lipolytic activity, a special formulation of enzymes, aerobic and anaerobic bacteria. [Porges & Mackenthun].

The most important factors affecting biological growth are temperature, availability of nutrients, oxygen supply, pH, presence of toxins and in the case of photosynthetic plants, sunlight. Bacteria are classified according to their optimum temperature range for growth. Mesophilic bacteria grow in a temperature of 10 to 40°C with an optimum of 37°C. Aeration tanks and trickling filters generally operate in the lower half of this range with wastewater temperatures of 20 to 25°C in warm climates. If cold well water serves as a water supply, wastewater temperature can be lower than 20°C. [Mark J. Hammer].

Municipal wastewaters commonly contain sufficient concentrations of carbon, nitrogen, phosphorus and trace nutrients to support the growth of microbial culture. Theoretically, a BOD-to-nitrogen-to-phosphorus ratio of 100/5/1 is adequate for aerobic treatment with small variations depend on the type of system and mode of operation. If wastewater contains a large volume of nutrient-deficient waste, supplemental nitrogen is generally supplied by the addition of anhydrous ammonia (NH_3) or ammonium nitrate (NH_4NO_3) and phosphate as phosphoric acid (H_3PO_4). [Sawyer McCarty].

Diffused and mechanical aeration basin must supply sufficient air to maintain dissolved oxygen for the biota to use in metabolizing the waste organics. The rate of microbial activity is independent of the dissolved oxygen concentration above a minimum critical value below which the rate is reduced by the limitation of oxygen required for respiration. The exact minimum depends on the type of activated sludge process and the characteristics of the wastewater being treated. [Sawyer McCarty]

Hydrogen ion concentrations have a direct influence on biological treatment system which operates best in a neutral environment. The general range of operation of aeration systems is between pH 6.5 and 8.5. Above this range microbial activity is inhibited and below pH 6.5 fungi are favored over bacteria in the competition for metabolizing the waste organics. Normally the bicarbonate buffer capacity of a wastewater is sufficient to prevent acidity and reduced pH, while carbon dioxide production by the microorganisms tends to control the alkalinity of high pH wastewaters. [Mark J. Hammer].

In an activated sludge process, waste organics serve as food for the bacteria and the small population of fungi that might be present. Some of the bacteria die and lyse, releasing their contents which are resynthesized by other bacteria. The secondary feeders (protozoa) consume several thousand bacteria for a single reproduction. The benefit of this predator-prey action is twofold:

- Removal of bacteria stimulates further bacterial growth, accelerating metabolism of the organic matter.
- The settling characteristics of the biological floc are improved by reducing the number of free bacteria in solution.

Control of the microbial populations is essential for efficient aerobic treatment. If wastewater were simply aerated, the liquid detention times would be intolerably long requiring time period of about five days at 29°C for 70 percent reduction. However, extraction of organic matter is possible within a few hours of aeration provided that a large number of microorganisms are mixed with wastewater. This is achieved by settling the microorganisms out of solution in a final clarifier and returning them to the aeration tank metabolize additional waste organics. [Mark J. Hammer].

2.2.1 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 before it is discharge into the main drain. 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 [PMT].

The first unit in the treatment operation is a primary screen. All wastewater entering the treatment will be channeled by gravity to the sump where stainless steel screen will be installed in order to trap unwanted large materials (15 mm spacing). 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 [PMT].

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. It will reduce the remaining floating matters and finer particles from entering the aeration tank [PMT].

Horizontal chamber with 10 minutes detention time will be provided to remove oil and grease. 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 [PMT].

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 [PMT].

The raw sewage will be treated in the aeration tank with forced aeration means of surface aerator. 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 [PMT].

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 [PMT].

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 [PMT].

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 [PMT].

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.

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 1: 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: Unit process description at UTP's STP

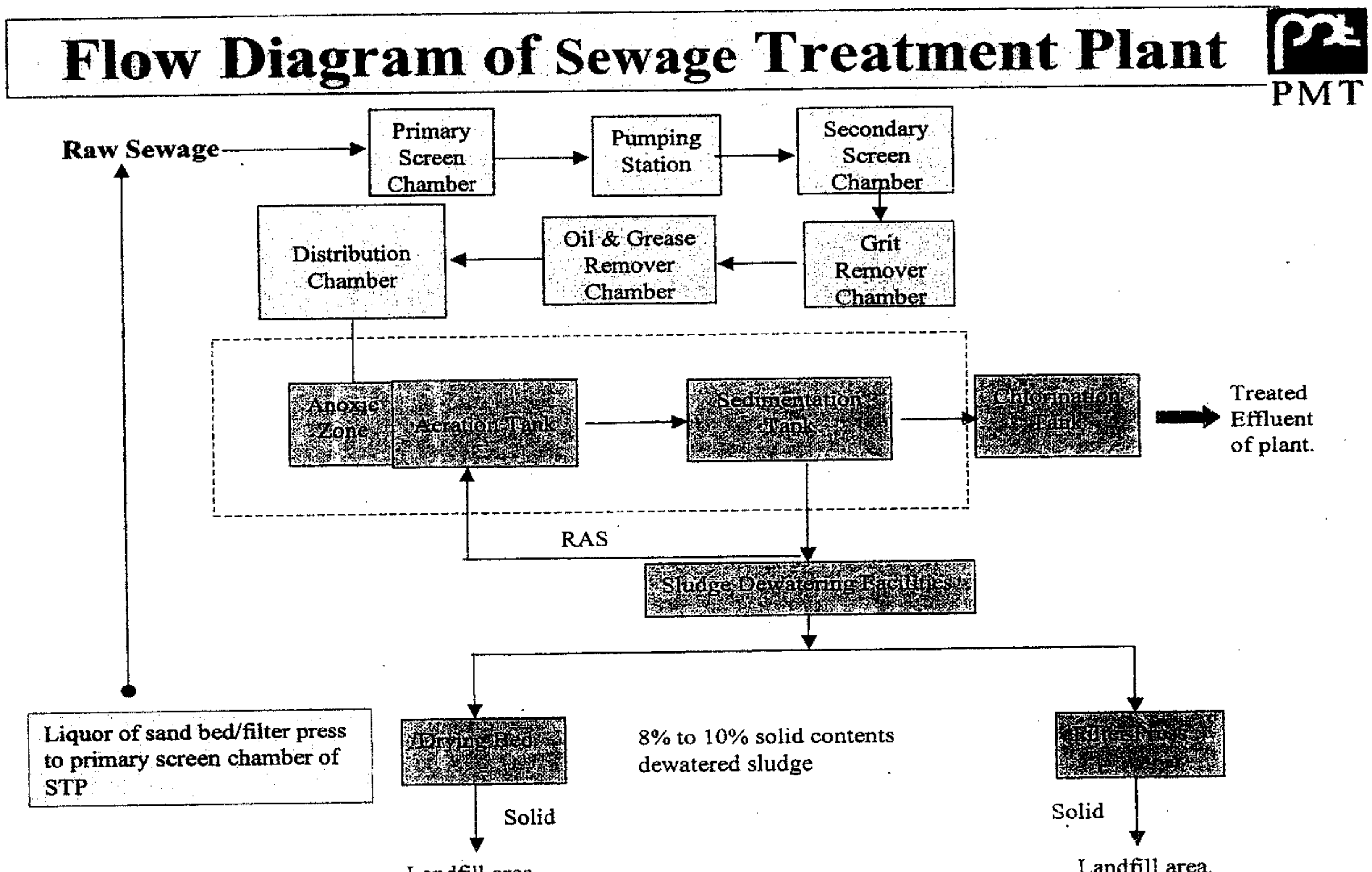

Figure 1: Flow Diagram of UTP Sewage Treatment Plant

2.2.2 UTP Oxidation Pond

There are various types of pond treatment processes which can be classified as aerobic stabilization pond, facultative pond, anaerobic pond and tertiary-maturation pond. Oxidation pond (facultative pond) is one of the most popular method uses to treat municipal wastewater. This type of pond has become very popular in small communities because their low construction and maintenance. The operating costs offer a significant financial advantage over other treatment methods because it's not requires much mechanical equipments. The disadvantages when applied this system are it requires large land area and result in odor if there is no sunlight. BOD removal also in low efficiency because the availability of algae in the effluent (Porges and Mackenthun,).

UTP oxidation pond was supposed to treat incoming influent to the complying standard that has been set by Environmental Quality Act (EQA), 1974 which is 20 mg/l of BOD and 50 mg/l of TSS. Figure 2 below showed the flow diagram for UTP oxidation Pond.

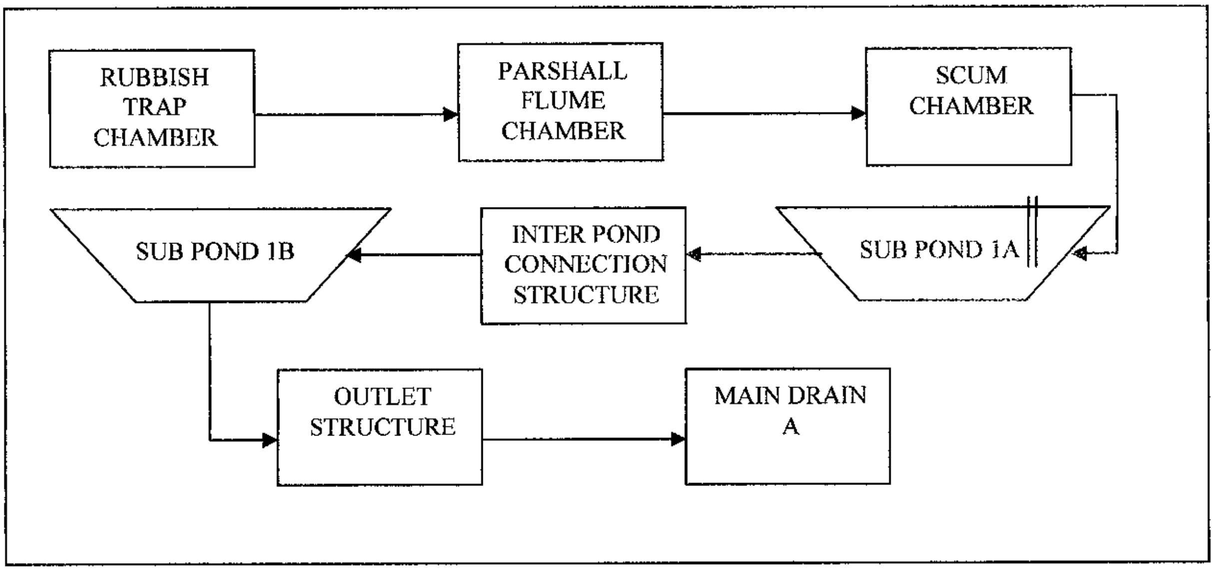

Figure 2: Flow Diagram for UTP's Oxidation Pond

The incoming influent will flow through rubbish trap chamber which act as coarse screen to filter all unwanted large materials such as rocks, branches, leaves, paper, plastics and rags. This rubbish trap chamber consists of uniform parallel bars or rods about 15 mm in spacing and must be manually cleaned. Next, wastewater will flow to the parshall flume. Parshall flume chamber was designed to measure a flowrate at the influent of the pond. Parshall flume is a particular type of venturi flume which constricts the throat of the flume to produce a differential head that is related to the flow rate. Is places a constriction on the stream and then drops the stream at the throat of the flume to produce a repeatable, cohesive surface to provide a flow measurement. The surface of the stream at the throat rises and falls linearly with the flow rate. A staff gauge is usually affixed to the inside surface of the flume for reference. [Crites & Tchobanoglous]

The sewage water then flows into scum chamber. The scum will be floating at the top of surface sewage water and heavier particles will settle down as sludge. The scum chamber consist of scum baffles attached to the weir, which retain solids floating on water surface inside the chamber and prevent from escaping into the pond. Sewage water will flow into oxidation pond and this sewage water will be treated by natural process involving algae and bacteria.

Ponds in which the stabilization of wastes is brought about by a combination of aerobic, anaerobic and facultative bacteria are known as facultative stabilization ponds. There are 3 zones exist in facultative ponds that are:

- A surface zone where aerobic bacteria and algae exist in a symbiotic relationship.
- An anaerobic bottom zone in which accumulated solids is decomposed by anaerobic bacteria.
- An intermediate zone that is partly aerobic and partly anaerobic, in which the decomposition of organic wastes is carried out by facultative bacteria.

Large solids settle out to form an anaerobic sludge layer. Soluble and colloidal organic materials are oxidized by aerobic and facultative bacteria using oxygen produced by algae growing abundantly near the surface. Carbon dioxide produced in the organic oxidation serves as a carbon source for the algae. Anaerobic breakdown of the solids in the sludge layer result in production of dissolved organics and gases such as CO_2, H_2S and CH_4, which are either oxidized by the aerobic bacteria or vented to the atmosphere. (Crites and Tchobanoglous)

The bacteria will release nutrients like nitrogen, phosphorus, carbon dioxide by metabolize the organic matter that existed in the pond. Then, algae will use all these compounds along with energy from sunlight for synthesis process and release oxygen into the water. The oxygen released by the algae then will take up by bacteria, thus closing the cycle. This type relationship between them is called *'symbiosis'* and it is common among organisms living in small ponds. (Metcalf & Eddy)

The bacteria decompose organic matter yielding inorganic nitrogen, phosphates and carbon dioxide. Algae use these compounds along with the energy from sunlight in photosynthesis releasing oxygen into solution. This oxygen is, in turn taken up by bacteria thus closing the cycle. The effluent from a stabilization pond contains suspended algae and excess bacterial decomposition end products. With increased temperature, the organic matter accumulated is rapidly decomposed by the bacteria using dissolved oxygen at a faster rate than can be absorbed from the air or supplied by algae. After a few days to several weeks, depending on climatic conditions and waste lagoon, the algae become reestablished and again supply oxygen to the bacterial cycle. [Mark J. Hammer]

Finally, the effluent from the oxidation pond will flows to the settling pond. This settling pond was design to hold the used water to allow time for the solids to settle. The clear effluent from this pond then will be discharged to the main drain. Note that this UTP oxidation pond was required to treat effluent to the Standard A which is 20 mg/l of BOD and 50 mg/l of TSS before it will be discharged.

2.3 Sampling Method

Proper sampling techniques are vital for accurate testing in evaluation studies. To be representative of the entire flow, samples should be taken where the wastewater is well mixed. An instantaneous grab sample conditions at the time of sampling only and cannot be considered to represent a longer time period since the characteristics of wastewater discharge is not stable. A composite sample is a mixture of individual grabs proportion according to the wastewater flow pattern. Compositing is commonly collecting individual samples at regular time interval such like an hour. A representative sample is then integrated by mixture together portions of individual samples relative to flow rates at sampling times. [Mark J. Hammer]

Composite sampling representing specified time periods are tested to appraise plant performance and loadings. Weekdays specimen collected over 24-hr period are most common. Average daily BOD and suspended solids data are used to calculate plant loading while mean influent and effluent concentrations yield treatment efficiencies. Integrated samples during the period of peak flow usually 8 to 12 hr depending on influent variations allow determination of maximum loading on treatment units. [Mark J. Hammer]

Sampling data are tabulated in a format convenient for calculating the portions of individual grab samples to be combined in composite. The time interval between collections of samples should be no greater than 2 hr and preferably 1 hr. The compositing time period and frequency of sampling defines the number of grab sample portions to be combined. The total volume of the composite sample desired depends on the kinds and number of laboratory tests to be performed. The volume of each grab sample collected must be adequate to provide the maximum portion required at maximum flow. [Metcalf & Eddy]

CHAPTER 3

METHODOLOGY AND PROJECT WORK

Samples from UTP's STP and UTP oxidation pond were taken frequently to analyze the wastewater characteristics in the laboratory. There are two types of sampling method that has been used which are grab sampling and composite sampling.

These samples will be taken once in a week at four different points which are at influent and effluent of the treatment plant for grab sampling method. On the composite sampling method, samples were taken for 24 hours in weekday and weekend at the influent of the treatment plant. All the samples were taken then will be tested for total suspended solids (TSS) and biochemical oxygen demand (BOD).

3.1 Experimental Work

The samples taken from the UTP's STP and UTP oxidation pond were examined in the laboratory for measuring the performance of treatment process at UTP's STP and UTP oxidation pond. There are two types of laboratory works that have been conducted on this semester which are:

1. Total Suspended Solids (TSS)
2. Biochemical Oxygen Demand (BOD)

The results that obtained from the laboratory works then will be compared with the theoretical data.

Point	Sources	Sampling Method	Frequency	Parameters
1	Influent of UTP's STP	Grab Sampling	Once in a week	BOD & TSS
2	Effluent of UTP's STP	Grab Sampling	Once in a week	BOD & TSS
3	Influent of UTP's Pond	Grab Sampling	Once in a week	BOD & TSS
4	Effluent of UTP's Pond	Grab Sampling	Once in a week	BOD & TSS
5	Influent of UTP's STP	Composite Sampling	Weekdays	BOD & TSS
6	Influent of UTP's STP	Composite Sampling	Weekends	BOD & TSS

Table 3: Points of wastewater sampling methods

3.1.2 Total Suspended Solids (TSS)

Main objective of the TSS test is to determine the weight of suspended solids existed in samples. The procedure steps for TSS experiment were discussed.

Aluminum foils for with and without filtration paper were weighted and recorded on the TSS form. Then, 500 ml of samples were mixed from the sample bottles for each point in a beaker. Measurement cylinders were used to measure 50ml samples from 500 ml of samples in the beaker.

Then, filtration units is set up as shown on figure 1.By using a forceps, the filtration paper was placed on the volumetric cone for the filtration process. The clapper was used to clap the filtration cylinder on the volumetric cone. The samples from the measurement cylinder were poured into the filtration unit in order to determine the suspended solids. After 10 minutes, the filter paper was removed from the filtration unit.

Figure 3: Filtration Units

Next, the filter paper and aluminum foils were dried in the oven for 20 minutes. The dried filter paper then was placed on the desiccator as shown on figure 2 for 10 minutes after it was removed from the oven. The dried filter paper with aluminum foils were being measured for the last time and recorded. The processes of determined total suspended solids (TSS) were repeated for each point that has been selected from the UTP's STP and UTP oxidation pond.

Figure 4: Desiccator

Total suspended solids then is calculated by using a formula that shown below:

$$TSS = \frac{(\text{Dried Filter Paper} + \text{Aluminum Foils}) - (\text{Filter Paper} + \text{Aluminum Foils})}{\text{Volume of samples}}$$

During the experiment, safety precaution should be emphasized in order to avoid an error during the experiment. There are several factors that should be followed to prevent any accident occur during the experiment. A safety glove and goggle must be wearing to avoid an accident.

Beside that, human and equipment errors should be minimized in order to get accurate results. The filtration papers and aluminum foils should be lifted by using forceps and not to be touched by using hands. The samples also should be stirred first before it will be poured into the filtration unit.

3.1.3 Biochemical Oxygen Demand (BOD)

Second laboratory works that have been conducted was the biochemical oxygen demand (BOD) test. The purpose of this experiment is to determine the amount of oxygen needed for the bacteria to degrade the organic matter in the wastewater.

Before conducted biochemical oxygen demand (BOD) experiments, distilled water must be aerated for at least 24 hours. Then, BOD meter was calibrated based on the manual as shown on figure 3a and 3b. After that, the standard that acts as references for this experiment were prepared by using distilled water that has been aerated.

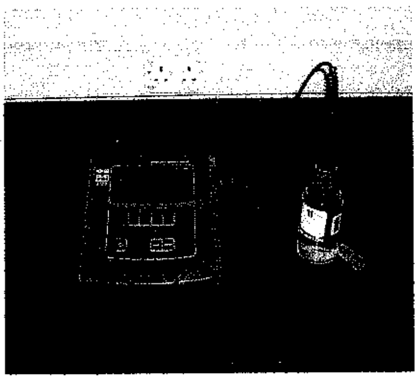

Figure 5a: BOD meter

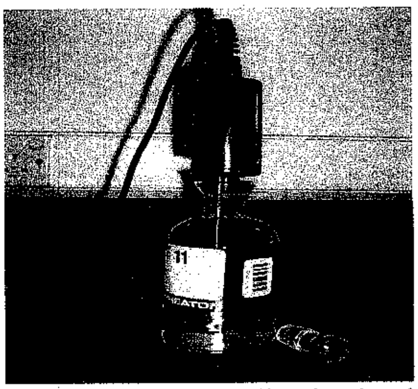

Figure 5b: BOD calibration bottle

In the standard of BOD test, a small sample of the wastewater to be tested is placed in a BOD bottle (volume = 300 ml). The bottle is then filled with dilution water saturated in oxygen and containing the nutrients required for biological growth. To ensure that meaningful results are obtained, the sample must be suitably diluted with specially prepared dilution water so that adequate nutrients and oxygen will be available during the incubation period. Normally, several dilutions are prepared to cover the complete range of possible values. The ranges of BOD that can be measured with various dilutions based on percentage mixtures and direct pipetting. Before the bottle is stoppered, the oxygen concentration in the bottle is measured. [Metcalf & Eddy]

After the bottle is incubated for 5 days at 20°C, the dissolved oxygen concentration is measured again. The BOD of the sample is the difference in the dissolved oxygen concentration values, expressed in milligrams per liter, divided by the decimal fraction of sample used. The computed BOD value is known as the 5 day, 20°C biochemical oxygen demand. When testing waters with low concentration of microorganisms, a seeded BOD test is conducted. The organisms contained in the effluent from primary sedimentation facilities are used commonly as the seed for the BOD test. When the sample contains a large population of microorganisms, seeding is not necessary. [Metcalf & Eddy]

Biochemical oxygen demand (BOD) will be calculated by using a formula that shown below:

$$BOD = \frac{\text{(Initial DO – Final DO) – (Blank Correction)}}{\text{Volume Used / Total Volume of BOD Bottle}}$$

During the experiment was conducted, preventative measure should be carefully done in order to eliminate errors. There are several factors that produce errors during the experiment such like the distilled water not aerated for 24 hours.

In order to conduct this BOD experiment, fresh samples from UTP's STP should be tested. When the experiments is conducted, several precautions should be concerned such like the tube, inner part of bottle and distilled water cannot be touched by hands to avoid contaminated. The stirrer of BOD meter also must be washed by distilled water after the initial D.O reading was taken. Note that, fully aerated distilled water will be used each time to calibrate the BOD meter.

CHAPTER 4

RESULTS AND DISCUSSION

The samples from UTP's STP and UTP oxidation pond were taken frequently [table 3] in order to determine the results of total suspended solids (TSS) and biochemical oxygen demand (BOD). During this semester, TSS and BOD experiment were done regularly in order to evaluate the performance of UTP's STP and UTP oxidation pond.

4.1 Total Suspended Solids (TSS)

Total Suspended Solids Experiment		
Location of Samples	Highest TSS (mg/l)	
	Influent	Effluent
UTP's STP	290	40
UTP Oxidation Pond	192	30
UTP's STP	74	32
UTP Oxidation Pond	74	36

Table 4: Results of TSS

There are four experiments that have been conducted for total suspended solids during this semester. From the results that obtained from experiment, a graph of TSS values against experiment was established. In the graph on figure 6, it is shown that a values for total suspended solid (TSS) at the influent of UTP's STP is around to the theoretical values which is 300 mg/l. The graph also shown experimental values of TSS at the influent of pond are quite different from the expectation which is only 178 mg/l. This might be happened because the samples were taken during peak-off hour where the oxidation pond just have a little of wastewater being flowed at that time.

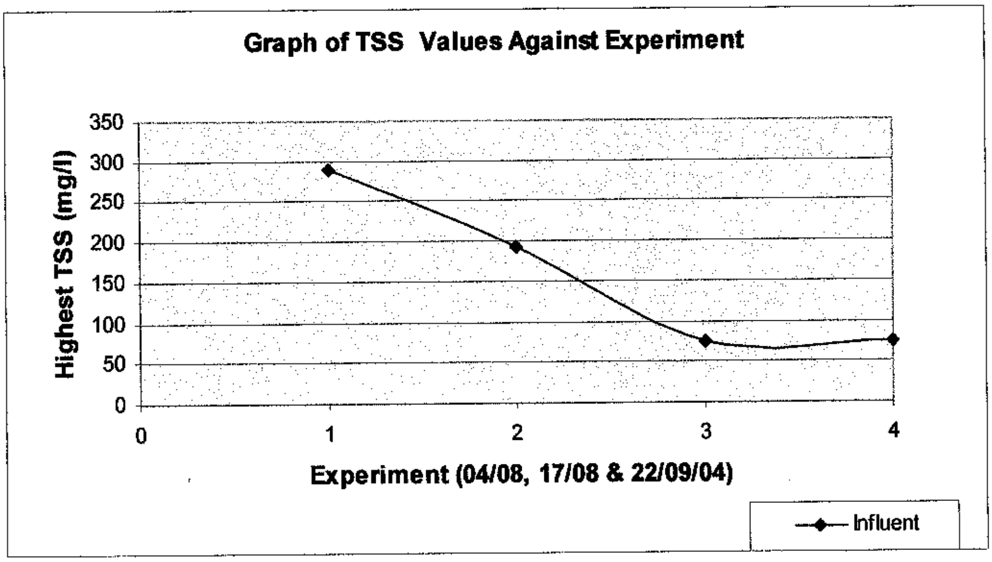

Figure 6: Graph of TSS Values at influent of UTP's STP and UTP Pond

At the end of august 2004, south pond of UTP oxidation pond was decommissioned and all the wastewater was diverted to the UTP Sewage Treatment Plant. Therefore, after august 2004, all the TSS experiments were being test at the influent of UTP's STP. The results that obtained will give a comparison between standard influent that usually flowed to the UTP's STP and currently influent that flowed after south pond of UTP oxidation pond was decommissioned.

On 22/09/2004, TSS experiment was conducted in order to determine the differences of influent at UTP's STP after south pond was shut down. From the grab sampling method that has been done, the result shows that maximum values of TSS just only 74 mg/l although wastewater at the south pond was diverted to the UTP's STP. This is because certain amount of wastewater is still being treated by the north pond of UTP oxidation pond other than UTP's STP. Beside that, small amount of influent also may happened because the samples were taken in the afternoon where there is just little quantity of wastewater were being flowed at that time.

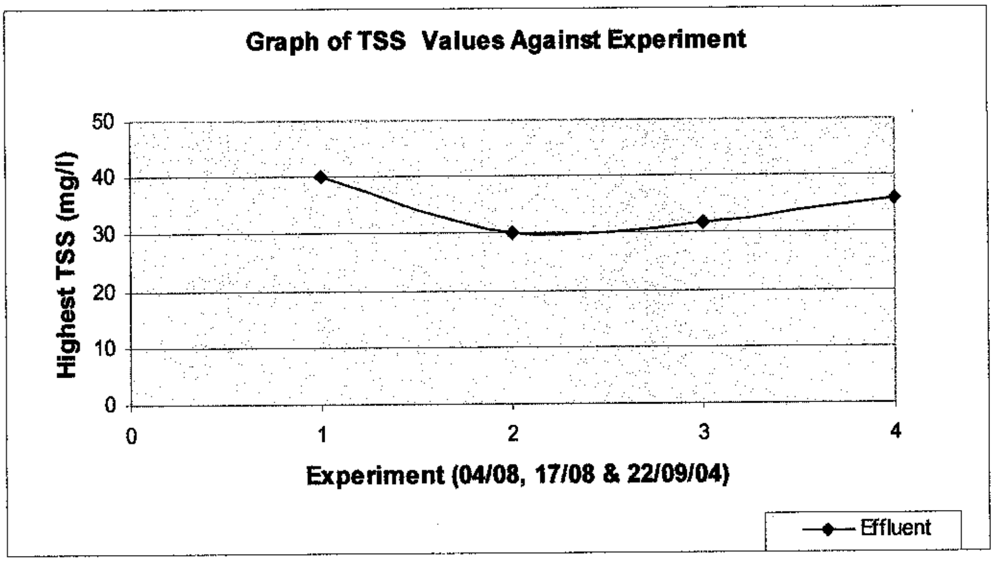

Figure 7: Graph of TSS Values at Effluent of UTP's STP & UTP Pond

Main concerned of this experiment is the effluent of UTP's STP and oxidation pond. These sewage treatment plant and oxidation ponds were designed for STANDARD A which is 20mg/l BOD and 50 mg/l TSS. From the graph, values that have been plot for effluent were met the standard which are below 50mg/l of TSS for all experiment.

The results on figure 7 show that highest value of TSS at effluent just only 40 mg/l. This result proves that UTP's STP is capable to treat all municipal wastewater below than 50 mg/l of TSS although unusable of chlorination tank and existing algae in the clarifier. Both of these problems will reduce the efficiency of treatment plant if it is not maintain regularly. The results assure that both treatments were capable to treat municipal wastewater to the Standard A effluent limit required.

In order to maintain a high level of treatments performance with the activated sludge process, special attention must be given to the controlling of the return activated sludge (RAS). The purpose of return activated sludge (RAS) is to maintain a sufficient concentration of activated sludge in the aeration tank so that the required degree of treatment can be obtained in the time interval desired.

Main problem that occurred to the UTP's STP is the malfunction of the return activated sludge (RAS) pump that leads to no sludge return from clarifier to the aeration tank. Since the malfunction of RAS pump, bacteria died in the aeration tank because there are no sludge recycles that makes low concentration of sludge (organic matter) for bacteria to eat. So, TSS at the aeration tank is low than expected because there are no organic matters (foods) for bacteria to degrade the oxygen in the aeration tank. By right, TSS at the aeration tank should be higher because there are increasing in organic matter from hour to hour for bacteria to eat when the wastewater flowed to the aeration tank. Beside that, over design of this UTP's STP also cause the TSS becomes lower at the aeration tank. This UTP's STP was designed for 23000 population equivalent whereas UTP population just 6000 to 8000 population equivalent only. Malfunction of RAS pump and over design of the UTP's STP makes bacteria died because insufficient foods in the aeration tank.

Composite sampling method also was applied at the influent of UTP's STP. This sampling method will illustrate the TSS values for 24 hours in a day. Graph below show the results for 24 hours sampling method.

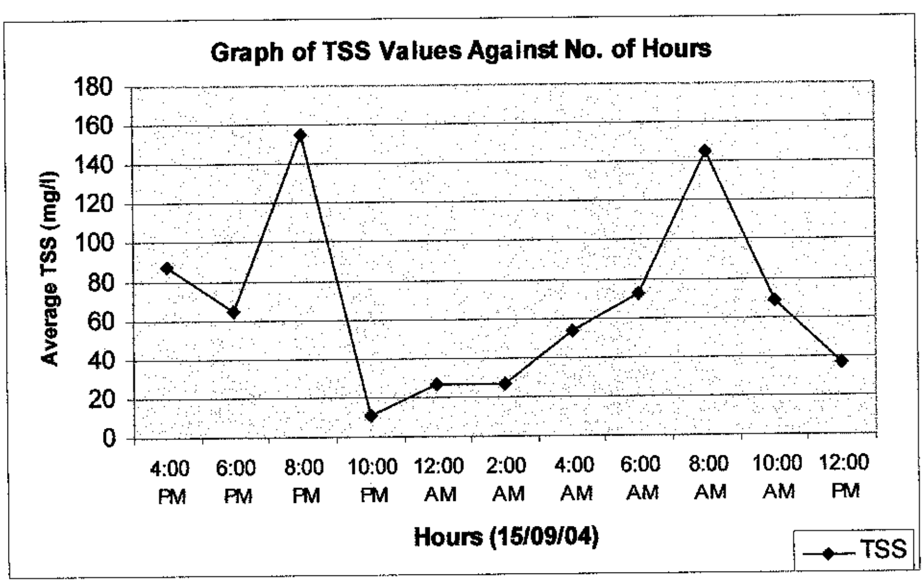

Figure 8: Graph of TSS Values for Composite Sampling Method

Figure 8 above show that maximum values of TSS were 155 mg/l at 8.00 P.M and 145 mg/l at 8.00 A.M in the morning. Higher TSS values at these hours were cause by the greater number of students used water to do their daily routine. At 8.00 P.M, many students take their bath before they go for dinner that contributes maximum number of TSS at that hour. Some of students might have a class at 8.00 A.M that make number of TSS values high in the morning.

From 10.00 P.M to 4.00 A.M in the morning, the graph showed a minimum value of TSS which are below than 50 mg/l. This is because most of the students were sleeping and not much water being used at that hour compare to others. From this graph, peak hour of wastewater being pumped to the UTP's STP can be predicted based on composite sampling method.

In order to determine the efficiency removal of TSS at the UTP's STP and UTP oxidation pond, percentage of removal were calculated on the table 5.

Location of Samples	Average TSS (Experiment1) (mg/l)		
	Influent	Effluent	(% Removal)
UTP's STP	256	35	86 %
UTP's Pond	178	24	87 %

Table 5: Percentage of TSS Removal at UTP's STP and Pond

From the experiment that has been conducted for total suspended solids at the treatment plant and oxidation pond, percentage of removal can be determined. The results show that 86 % of suspended solids were removed at the UTP's STP as the wastewater flows from the influent to the effluent. At the UTP oxidation pond, 87 % of suspended solids were removed. This showed that UTP's STP and UTP oxidation pond has successful in order to remove suspended solids from the influent until to the effluent.

Location of Samples	Average TSS (mg/l)		
	Influent	Effluent	(% Removal)
UTP's STP	58	28	52 %

Table 6: Percentage of TSS Removal at UTP's STP

Table 6 above show the percentage removal of total suspended solids after south pond was decommissioned. The result show there is only 52 % of TSS was removed at the effluent of UTP's STP. This less efficiency removal may occur because the raw sewage at influent was only 58 mg/l. So, there just little amount of wastewater is being treated at that time (peak-off hour).

Figure 9 below show a graph of TSS values at three different points before the south pond was closed. The graph shows that values of TSS were drop as the wastewater flowed from the influent to the effluent of pond. The graph also proves that UTP oxidation pond was capable to treat wastewater below complying standard which is 50mg/l of TSS. All calculation of TSS was shown in the Appendices I.

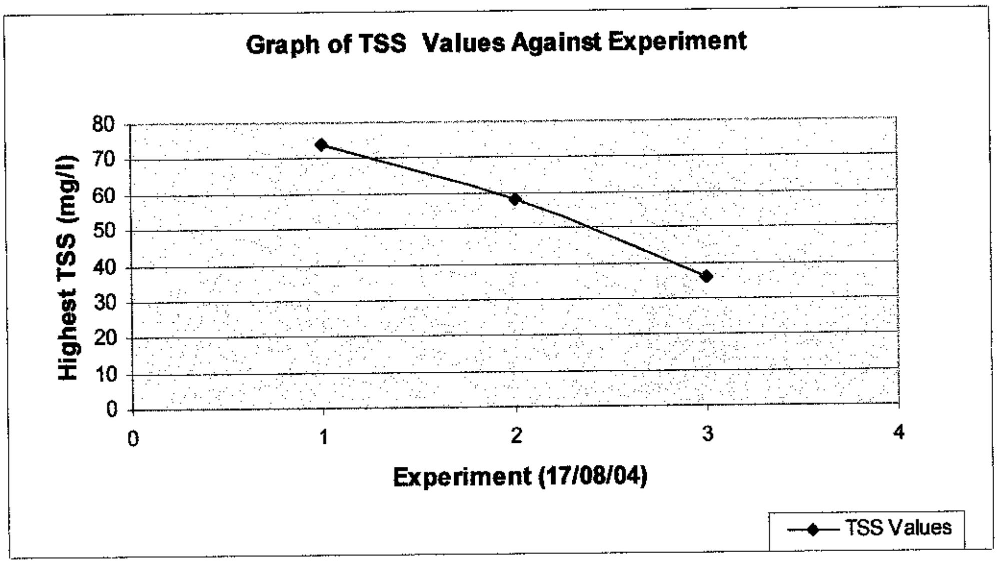

Figure 9: Graph of TSS Values at UTP Oxidation Pond

4.2 Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand (BOD) is the amount of oxygen needed for the bacteria to degrade the organic matter in the wastewater. The design basis for incoming raw sewage and effluent for biological oxygen demand at the UTP's STP and UTP oxidation pond is refer to standard A of 250 mg/l at influent and 20mg/l at effluent.

There are eight experiments were conducted on biochemical oxygen demand (BOD). Three of these experiments were done on composite sampling whereas others were made from grab sampling method. On the grab sampling method, two tests were made before south pond was decommissioned. After south pond was shut down, all samples were taken from UTP Sewage Treatment Plant including from composite sampling method. Based on the experiments that have been conducted for each sampling method, a graph of BOD values will be developed. Table 7 below show the results of BOD values at the influent and effluent for both treatment plants.

Biochemical Oxygen Demand Experiment		
Location Of Samples	Highest BOD (mg/l)	
	Influent	Effluent
UTP Oxidation Pond	67	16
UTP's STP	61	12
UTP Oxidation Pond	108	27
UTP's STP	72	17
UTP's STP	93	25
UTP's STP	75	16
UTP's STP	102	11

Table 7: Results of BOD

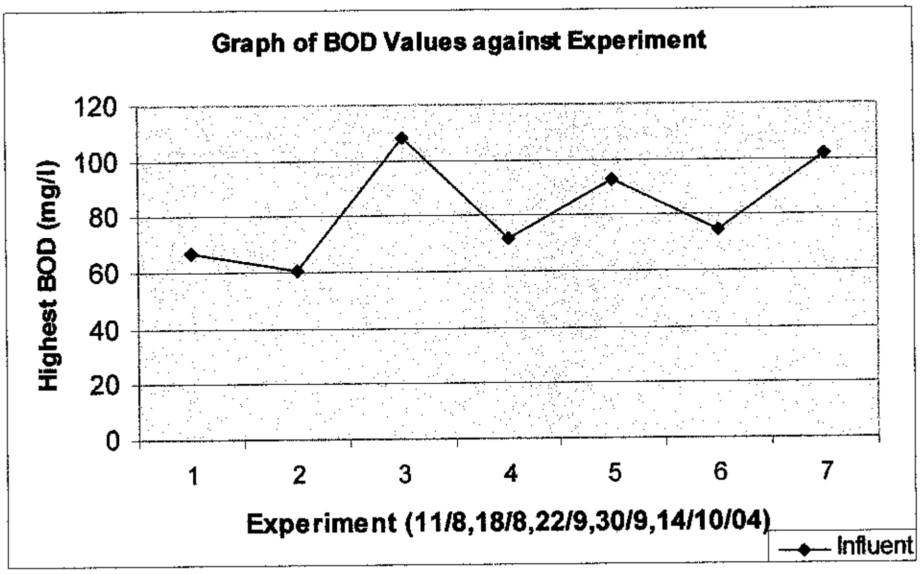

Figure 10: Graph of BOD Values at Influent

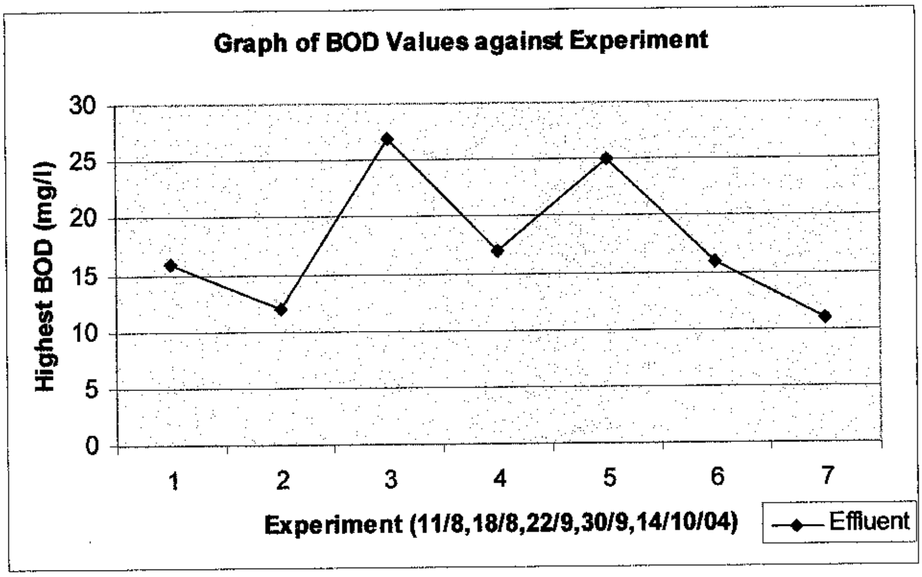

Figure 11: Graph of BOD Values at Effluent

Graph above show the results of BOD values at influent and effluent for all experiments that have been conducted during this semester. The results consists both BOD values at influent and effluent of UTP Sewage Treatment Plant and UTP Oxidation Pond.

There are two experiments that have been conducted at the UTP oxidation pond on 11/08/04 and 18/08/04 before south pond was commissioned. From the graph, it is shown that maximum values of BOD at influent of UTP oxidation pond just only 67 mg/l on experiment 1 and 108 mg/l on experiment 2. Lower values of BOD at the influent occur because the samples were taken at the afternoon where small quantity of wastewater was being flowed at that time.

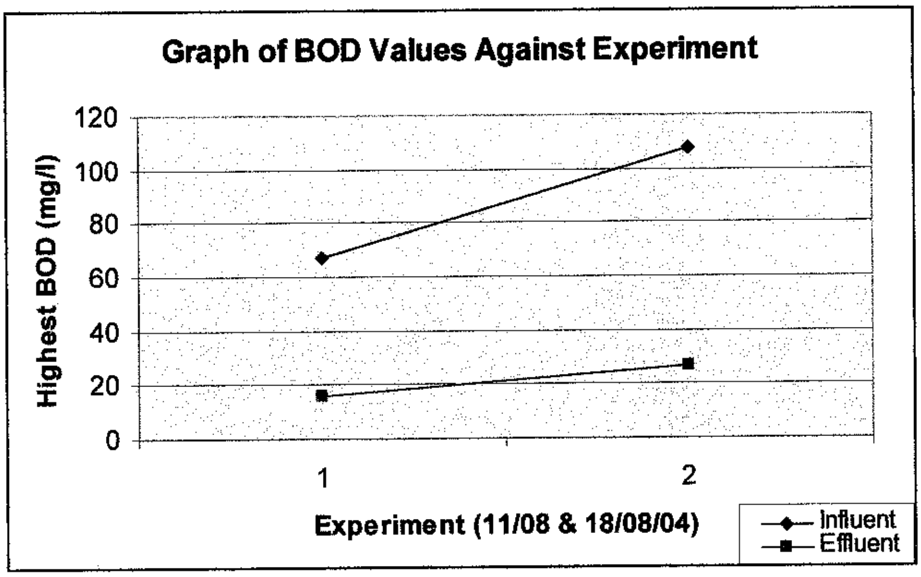

Figure 12: Graph of BOD Values at UTP Oxidation Pond

Figure 12 show that effluent at the UTP oxidation pond was greater than the standard which is 27 mg/l. These experimental results show that UTP oxidation pond did not comply with the standard requirement of 20mg/l of BOD. This may be due to excessive algae growth in shallow area at the pond. It also found that no maintenance works were scheduled to remove the accumulated scum at the effluent of the UTP oxidation pond. Scum may consists of the floatable materials that may contain grease, vegetable and mineral oils, waxes, soap, food wastes, hair, paper, grit particles and similar materials. Scum is not only unsightly but may contain organic material that can cause oxygen depletion and be a source of odors.

Tones of waste materials also were found trapped and clogged in the bar screen chamber. After raining day, water accumulated on the top of the waste material and created bad odor. This showed UTP oxidation pond was lack in maintenance that will cause BOD didn't fully remove as the wastewater flows from the influent to the effluent.

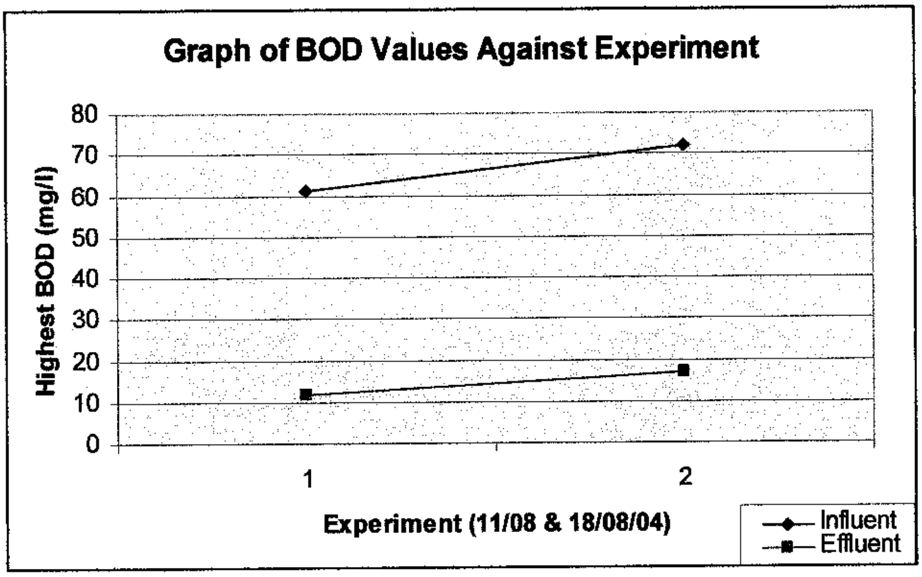

Figure 13: Graph of BOD Values at UTP's STP

From figure 13, it is shown that there just a small amount of wastewater were being pumped during the samples were taken. The graph shows there only 72 mg/l and 61 mg/l of BOD for both experiment was calculated. Main factor that contribute to the lower BOD values are because grab sampling method were done on peak off hour. Hence, the samples didn't contain much BOD values. Another probability is the wastewater has been watering during the cleaning process of grit chambers.

Similar with TSS, BOD at effluent of UTP's STP is the important things in order to evaluate the performance of the treatment. From the graph that has been plotted on figure 11, BOD at the effluent for UTP's STP was meet the standard which is below 20 mg/l of BOD. Both experiment satisfied that BOD values were lower than the required limit. The results prove that UTP's STP is good to treat all municipal wastewater from UTP to the discharge main drain.

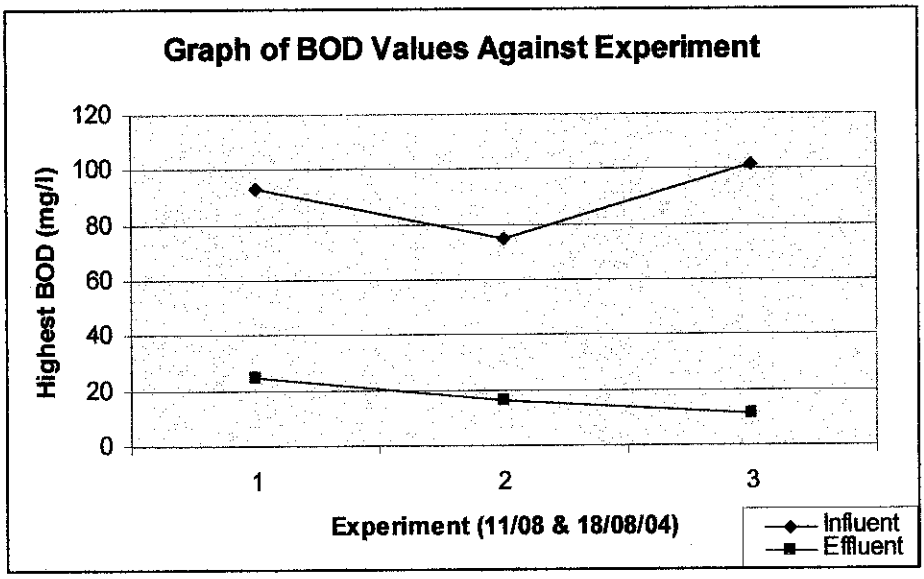

Figure 14: Graph of BOD Values at Influent & Effluent of UTP's STP

There are three experiments were conducted at the influent and effluent of UTP's STP after all the wastewater from UTP has been directed to UTP's STP. From this graph, experiment 3 give the highest value at the influent which is about 102 mg/l. The results show that samples were taken during peak hour where large amount of wastewater was being pumped at that time.

Experiment 1 and 2 stated that BOD values were greater than experiments that have been done before south pond was decommissioned which are 93 mg/l and 75 mg/l of BOD. Although both experiments didn't give a maximum BOD values, these results also can prove that after south pond was diverted to the UTP's STP, BOD results at the influent was increase higher than normal values. The results show that wastewater treating capacity of UTP's STP was increased after decommissioned of south pond.

Figure 14 above also show the results of BOD values at effluent of the UTP's STP. Three experiments from grab sampling method have been test to analyze the performance of UTP's STP.

From the graph, effluent of experiment 2 and 3 show this UTP's STP was complies with Standard A. The graph stated that BOD values at effluent are below than 20 mg/l which are only 16mg/l and 11 mg/l for both experiments. The results for both experiment 2 and 3 verify that UTP's STP was able to treat large amount of wastewater to the satisfied effluent limit.

On experiment 1, the graph shows that BOD value at effluent was greater than Standard A which is 25 mg/l. This experimental value show UTP's STP was inconsistencies in treating BOD to the standard required. Thus, this UTP's STP is not good enough to treat BOD to the Standard A.

After south pond was commissioned, it is important to determine the differences of BOD values before and after the closing of pond. Therefore, a composite sampling method has been placed at the influent of UTP's STP. The samples from this sampling method were taken for weekdays and weekends to analyze in the laboratory. Results from laboratory works was shown on figure 15.

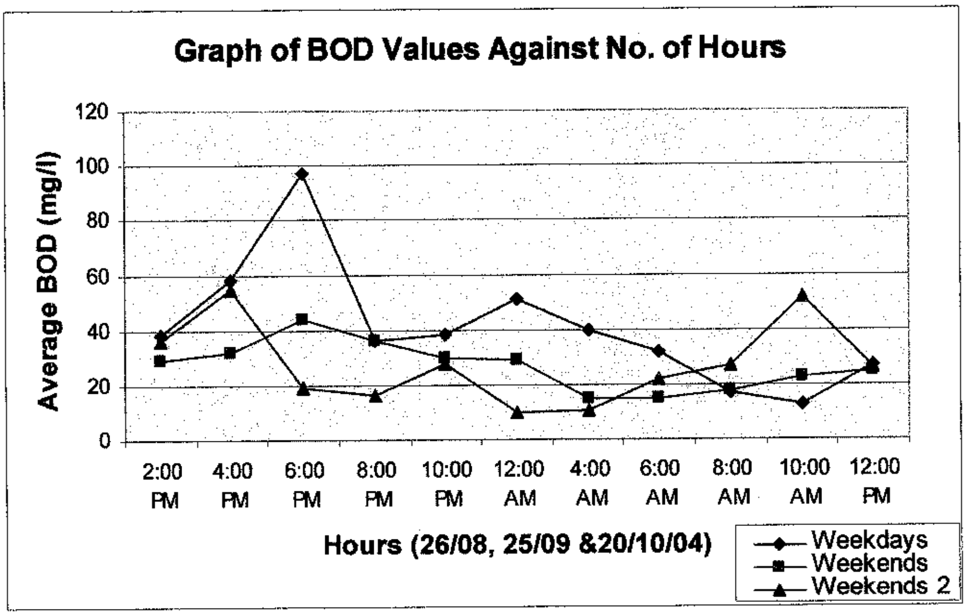

Figure 15: Graph of BOD Values for Composite Sampling Method

A composite sample also was placed at the influent of treatment plant to illustrate the BOD values for 24 hours in a day. The sample was placed during the weekdays and weekends for a comparison of BOD values between both periods.

On weekends, there are two experiments that have been conducted. Experiment 2 for weekends was done after north pond of UTP oxidation pond was completely commissioned. Another two experiments both for weekdays and weekends were done before north pond was shut down.

The highest BOD values for both weekdays and weekends are at 6.00 P.M which are 97 mg/l and 44 mg/l. Main reason that increase BOD values at that hour were cause by the greater number of students used water in the evening. During weekends, the graph show a lower value of BOD compared to weekdays. This is because some of students were went out to Ipoh or gone back to their hometown on weekends. Usually on weekends, most of students wake up late than weekdays. The factor contributes to higher BOD values on weekends than weekdays at 10.00 A.M.

Figure 15 above also show BOD values for composite sampling method after north pond was shut down (red line). The maximum BOD values that obtained from this sampling method were 55 mg/l at 4.00 P.M and 52 mg/l at 10.00 A.M whereas minimum values that recorded during weekend were 10 mg/l at 12.00 A.M. The results show that students were using much water at late evening and early morning to accomplish their daily routine. From 12.00 A.M to 4.00 A.M in the morning, the graph showed a minimum values where less students were using water at that time.

On 2nd October 2004, UTP oxidation pond was completely commissioned when the north pond was ordered to shut down. Therefore, all wastewater was diverted to the UTP Sewage Treatment Plant. After the north pond was closed, an experiment for grab sampling method also has been done to evaluate the performances of UTP's STP. Graph below show a result for grab sampling method after whole UTP oxidation pond was shut down.

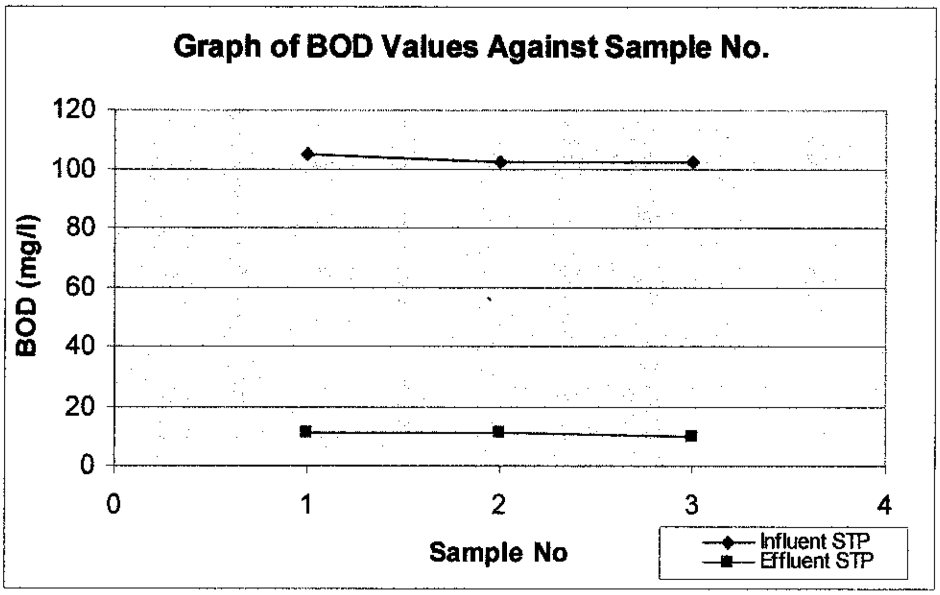

Figure 16: Graph of BOD Values at Influent and Effluent of UTP's STP

Figure 16 above show BOD values of UTP's STP after the north pond was shut down. From this graph, maximum values of BOD at the influent were 105 mg/l. The experimental result show that BOD values were greater than typical values after north pond was commissioned. This result proves that an increasing of BOD values at influent as all the wastewater at UTP were diverted to the UTP's STP.

As shown on the graph, effluent of UTP's STP still comply with the Standard A although large amount of wastewater has been pumped to UTP's STP. This UTP's STP was capable to treat effluent to 11 mg/l. This proves that UTP's STP is still good enough to treat UTP municipal water even though some of the equipment and tank at UTP's STP were unusable.

Location of Samples	BOD(Experiment1) (mg/l)			BOD (Experiment 2) (mg/l)		
References	Influent	Effluent	(% Removal)	Influent	Effluent	(% Removal)
UTP's STP	53	10	81 %	71	16	78 %
UTP's Pond	62	16	74 %	101	26	74 %

Table 8: Percentage of BOD Removal at UTP's STP and Pond

The results show that 81 % and 78 % of BOD were removed at the UTP's STP as the wastewater flows from the influent to the effluent. At the UTP oxidation pond, there only 74% of BOD were removed for both experiment. This showed that the performance of the UTP oxidation pond is not good enough to remove BOD because good treatment methods should be able to remove BOD compound between the ranges from 80% - 100%.

Location of Samples	Average BOD (mg/l)		
References	Influent	Effluent	(% Removal)
UTP's STP	88	23	74 %
	73	15	79 %
	102	11	89 %

Table 9: Percentage of BOD Removal at UTP's STP

Table 9 above show the percentage removal of biochemical oxygen demand after south and north pond was commissioned. The result show that after both ponds was closed, the percentage of BOD removal still around at same percent. This proves that UTP's STP is capable to treat municipal wastewater at complying standard although all the wastewater has been diverted to UTP's STP. All the calculations for BOD were shown on appendices I.

CHAPTER 5

CONCLUSION

Several laboratory works such as biological oxygen demand (BOD) and total suspended solids (TSS) have been done to complete the objectives for this final year project. Results of biological oxygen demand, total suspended solids and percentage of removal of TSS and BOD later then were been used to monitor the performance at the UTP Sewage Treatment Plant (UTP's STP) and UTP Oxidation Pond. This experimental results were been compared with the theoretical values in order to determine the efficiency of UTP's STP and UTP oxidation pond.

From the experiments that have been conducted, both treatment show inconsistencies in treating biochemical oxygen demand (BOD) and total suspended solids (TSS). Some results were meet the standard required whereas few result were greater than the standard A effluent limit. This is because some equipment at UTP's STP was lack in maintenance. In order to increase the efficiency of the treatment plant and oxidation pond, the contractor must fully operate all the facilities in the treatment plant and oxidation pond. A series of improvement and maintenance program should be implemented for upgrading the performance of both treatments.

In conclusion, study for evaluation the performance of various parameters used to characterize wastewater for UTP Sewage Treatment Plant and UTP oxidation pond give advantages to the UTP itself. Therefore, further study and research will be arranged in order to improve the performance of the UTP Sewage Treatment Plant. And UTP Oxidation Pond

RECOMMENDATIONS

In order to improve the performance of University Technology Petronas Sewage Treatment Plant (UTP's STP), all the equipments at UTP's STP such like clarifier and chlorination tank should be maintain regularly. The existing algae growth at the clarifier must be remove to keep clarifiers functioning. Beside that, the contractor also must usually maintain the facilities in UTP's STP such like inlet chamber, grit and grease chamber, distribution chamber, anoxic zone, aeration tank, clarifier and chlorination tank.

If the oxidation pond will be operated for the next time, it should be supported with aerator that installed in the pond. The essential function of this treatment process is waste conversion. Oxygen is usually supplied by means of surface aerators or diffused air units. As with other suspended growth systems, the turbulence created by the aeration devices is used to maintain the content of the basin in suspension.

Civil engineering laboratory also should provide more apparatus and equipments to students for completing their laboratory works. Lack of equipments such like BOD bottles and vacuum pump will results lagging to perform laboratory works. The technicians should regularly check the apparatus at the laboratory to maintain the effectiveness of laboratory works. Lastly, civil engineering department should provide a vehicle for students to complete their final year project rather than using own transportation.

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APPENDICES I

LABORATORY WORKS

RESULTS

Total Suspended Solids Experiment 1 (04/08/04)

Grab Sampling Method

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
Influent STP	50 50 50	2.5758 2.575 2.5644	2.5878 2.5869 2.5789	240 238 290	256
Effluent STP	50 50 50	2.5586 2.5711 2.5771	2.5601 2.5731 2.5789	30 40 36	35
Influent Pond	50 50 50	2.5633 2.5754 2.5756	2.5712 2.5846 2.5852	158 184 192	178
Effluent Pond	50 50 50	2.5742 2.5709 2.5724	2.5757 2.5724 2.573	30 30 12	24

Total Suspended Solids Experiment 2 (17/08/04)

Grab Sampling Method

Sample	Volume of sample (ml)	Weigh of pan + filter paper before drying (mg)	Weigh of pan + filter paper after drying (mg)	TSS (mg/l)	Avg TSS mg/l
IP1	25 25 25	2856.9 2856.8 2863.2	2858.6 2858.3 2864.9	68 60 68	65
	50 50 50	2881.9 2887.4 2898.9	2885.2 2891.1 2902.3	66 74 68	69
	25 25 25 25	2874.8 2869.1 2869 2877	2876.5 2870.7 2870.4 2878.5	68 64 56 60	62
IP2	25 25 25	2905.1 2906.6 2913	2906.2 2907.7 2914.2	44 44 48	45
	50 50 50	2923 2923.2 2923.3	2925.9 2926 2926.2	58 56 58	57
	50 50 50	2863.4 2812.6 2920	2866 2815.5 2922.7	52 58 54	55
IP3	25 25 25	2921.3 2917.9 2929.9	2922.1 2918.8 2930.7	32 36 32	33
	50 50 50	2926.7 2889.6 2883.3	2927.9 2890.6 2884.5	24 20 24	23

Total Suspended Solids Experiment 3 (15/09/04)

Composite Sampling Method

Time	Volume of Samples	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
4:00 PM	50 ml 50 ml 50 ml	2.573 2.5666 2.5763	2.5775 2.5714 2.5802	90 96 78	88
6.00 PM	50 ml 50 ml 50 ml	2.5777 2.9234 2.9273	2.5809 2.9269 2.9304	64 70 62	65
8:00 PM	50 ml 50 ml 50 ml	2.9297 2.5586 2.5767	2.9369 2.5676 2.5837	144 180 140	155
10:00 PM	50 ml 50 ml 50 ml	2.9248 2.5712 2.5737	2.9253 2.5719 2.5742	10 14 10	11
12:00 AM	50 ml 50 ml 50 ml	2.5647 2.8639 2.5673	2.5664 2.865 2.5686	34 22 26	27
2:00 AM	50 ml 50 ml 50 ml	2.5589 2.9288 2.921	2.5601 2.9302 2.9224	24 28 28	27
4.00 AM	50 ml 50 ml 50 ml	2.927 2.5648 2.5678	2.9305 2.5671 2.5701	70 46 46	54
6.00 AM	50 ml 50 ml 50 ml	2.5761 2.5716 2.5776	2.5786 2.5751 2.5825	50 70 98	73
8.00 AM	50 ml 50 ml 50 ml	2.5693 2.5753 2.9274	2.5756 2.5857 2.9325	126 208 102	145
10.00 AM	50 ml 50 ml 50 ml	2.9183 2.5779 2.9301	2.9218 2.5815 2.9333	70 72 64	69
12.00 PM	50 ml 50 ml 50 ml	2.571 2.5781 2.9287	2.5729 2.5797 2.9307	38 32 40	37

Total Suspended Solids Experiment 4 (22/09/04)

Grab Sampling Method

Sample	Volume of samples	Weigh of pan + filter paper before drying (g)	Weigh of pan + filter paper after drying (g)	TSS (mg/l)	Avg TSS mg/l
INFLUENT STP	50 ml	2.5769	2.5798	58	58
	50 ml	2.9222	2.9254	64	
	50 ml	2.9284	2.9321	74	
	50 ml	2.8053	2.8082	58	
	50 ml	2.83	2.8322	44	
	50 ml	2.8084	2.8108	48	
EFFLUENT STP	50 ml	2.9164	2.9178	28	28
	50 ml	2.9269	2.9284	30	
	50 ml	2.5698	2.5713	30	
	50 ml	2.5769	2.5781	24	
	50 ml	2.9273	2.9289	32	
	50 ml	2.9232	2.9244	24	

Biochemical Oxygen Demand Experiment 1 (11/08/04)

Grab Sampling Method

SAMPLE	BOTTLES ID	VOLUME OF SAMPLES	INITIAL D.O	FINAL D.O	BLANK CORRECTION	BOD (mg/l)	AVERAGE BOD
BLANKS	18 10 150 17		6.49 6.49 6.45 6.49	6.07 6.02 6.14	0.42 0.47 0.35		
INFLUENT POND	16 20 17	10 ml 10 ml 10 ml	6.34 6.3 6.3	4.1 3.86 3.71		57 63 67	62
EFFLUENT POND	8 6 9	20 ml 20 ml 20 ml	6.36 6.34 6.36	4.96 4.95 4.99		16 16 15	16
	24 22 16	50 ml 50 ml 50 ml	6.35 6.35 6.36	3.53 3.48 3.52		15 15 15	15
INFLUENT STP	22 167 13	10 ml 10 ml 10 ml	6.25 6.24 6.26	4.25 4.28 3.88		50 48 61	53
EFFLUENT STP	7 2 164	20 ml 20 ml 20 ml	6.26 6.27 6.25	5.24 5.24 5.21		10 10 10	10
	5 10 152	50 ml 50 ml 50 ml	6.14 6.14 6.14	4.28 3.87 4.32		9 12 9	10

Biochemical Oxygen Demand Experiment 2 (18/08/04)

Grab Sampling Method

SAMPLE	BOTTLES ID	VOLUME OF SAMPLES	INITIAL D.O	FINAL D.O	BLANK CORRECTION	BOD (mg/l)	AVERAGE BOD
BLANKS	8 9 20		8.68 8.69 8.65	8.54 8.47 8.5	0.14 0.22 0.15		0.145
INFLUENT POND	16 12 22	10 ml 10 ml 10 ml	8.56 8.56 8.56	5.48 5.04 5		88 101 102	97
	10 167 24	20 ml 20 ml 20 ml	8.36 8.38 8.39	1.04 1.29 1.33		108 104 104	105
EFFLUENT POND	5 15 6	50 ml 50 ml 50 ml	8.82 8.8 8.79	4.41 4.32 4.49		26 26 25	26
	17 13 12	70 ml 70 ml 70 ml	8.74 8.78 8.67	2.6 3.1 2.26		26 24 27	25
INFLUENT STP	18 3 152	10 ml 10 ml 10 ml	8.6 8.58 8.57	6.13 6.03 6.25		70 72 65	69
	17 10 8	20 ml 20 ml 20 ml	8.45 8.44 8.45	3.6 3.49 3.48		71 72 72	72
EFFLUENT STP	24 168 150	50 ml 50 ml 50 ml	8.14 8.14 8.11	5.3 5.29 5.39		16 16 15	16
	22 4 14	70 ml 70 ml 70 ml	7.86 7.85 7.91	3.9 3.87 3.88		16 16 17	16

Biochemical Oxygen Demand Experiment 3 (26/08/04)

Composite Sampling Method

SAMPLE	BOTTLES ID	VOLUME OF SAMPLES	INITIAL D.O	FINAL D.O	BLANK CORRECTION	BOD (mg/l)	AVERAGE BOD
BLANKS	24 17 5		8.75 8.74 8.75	8.2 8.21 8.21	0.55 0.53 0.54		0.54
2:00 PM	167 2 150	20 ml 20 ml 20 ml	8.35 8.4 8.37	5.42 5.31 5.22		36 38 39	38
4.00 PM	21 17 10	20 ml 20 ml 20 ml	8.3 8.3 8.34	3.97 3.9 3.87		57 58 59	58
6.00 PM	9 18 14	20 ml 20 ml 20 ml	8.23 8.25 8.26	1.35 1.19 1.17		95 98 98	97
8.00 PM	3 4 152	20 ml 20 ml 20 ml	8.3 8.3 8.34	5.18 5.57 5.44		39 33 35	36
10.00 PM	6 7 60	20 ml 20 ml 20 ml	8.29 8.29 8.27	5.02 5.16 5.55		41 39 33	38
12.00 AM	11 12 13	20 ml 20 ml 20 ml	8.31 8.26 8.29	4.26 4.38 4.38		53 50 51	51
4.00 AM	1 4 16	20 ml 20 ml 20 ml	8.11 8.06 8.1	4.52 4.59 4.49		42 39 40	40
6.00 AM	23 22 14	20 ml 20 ml 20 ml	8.07 8 8.1	5.27 5.48 5.51		31 32 32	32
8.00 AM	12 20 3	20 ml 20 ml 20 ml	8.05 8.15 8.12	5.92 6.64 6.84		24 15 11	17
10.00 AM	11 19 23	20 ml 20 ml 20 ml	8.17 8.24 8.23	6.66 6.93 6.89		15 12 12	13
12.00 PM	2 18 146	20 ml 20 ml 20 ml	8.2 8.18 8.2	5.41 6.21 6.02		34 21 25	27

Biochemical Oxygen Demand Experiment 4 (22/09/04)

Grab Sampling Method

SAMPLE	BOTTLES ID	VOLUME OF SAMPLES	INITIAL D.O	FINAL D.O	BLANK CORRECTION	BOD (mg/l)	AVERAGE BOD
BLANKS	19		8.62	8.19	0.43		0.4
	17		8.61	8.17	0.44		
	22		8.61	8.24	0.37		
INFLUENT STP	21	20 ml	8.3	2.29		84	88
	24	20 ml	8.37	1.99		90	
	17	20 ml	8.36	1.8		92	
	16	20 ml	8.39	2.13		88	
	14	20 ml	8.39	2.17		87	
	47	20 ml	8.41	2.38		84	
	12	20 ml	8.37	2.11		88	
	11	20 ml	8.37	2.05		89	
	4	20 ml	8.33	1.71		93	
EFFLUENT STP	21	50 ml	8.04	3.42		25	23
	167	50 ml	8.08	3.73		24	
	23	50 ml	8.07	3.66		24	
	8	50 ml	8.09	3.89		23	
	5	50 ml	8.08	3.76		24	
	10	50 ml	8.06	3.91		23	
	14	50 ml	8.04	3.88		23	
	15	50 ml	8.09	3.93		23	
	7	50 ml	8.05	3.61		24	

Biochemical Oxygen Demand Experiment 5 (30/09/04)

Grab Sampling Method

SAMPLE	BOTTLES ID	VOLUME OF SAMPLES	INITIAL D.O	FINAL D.O	BLANK CORRECTION	BOD (mg/l)	AVERAGE BOD
BLANKS	70		8.56	8.18	0.38		0.3
	16		8.43	8.21	0.22		
	11		8.42	8.26	0.16		
INFLUENT STP	47	20 ml	8.26	2.86		75	73
	14	20 ml	8.28	3.08		72	
	21	20 ml	8.27	3.09		72	
	10	20 ml	8.24	2.7		77	
	14	20 ml	8.25	3.05		72	
	4	20 ml	8.28	3.05		72	
	17	20 ml	8.23	3.1		71	
	7	20 ml	8.26	2.97		73	
	22	20 ml	8.25	3.19		70	
EFFLUENT STP	19	50 ml	7.84	5.06		14	15
	23	50 ml	7.84	4.97		15	
	17	50 ml	7.86	5.04		15	
	8	50 ml	7.86	4.99		15	
	12	50 ml	7.92	5.22		14	
	15	50 ml	7.84	4.99		15	
	21	50 ml	7.85	5.04		14	
	5	50 ml	7.85	4.85		16	
	24	50 ml	7.9	4.98		15	

Biochemical Oxygen Demand Experiment 6 (25/09/04)

Composite Sampling Method

SAMPLE	BOTTLES ID	VOLUME OF SAMPLES	INITIAL D.O	FINAL D.O	BLANK CORRECTION	BOD (mg/l)	AVERAGE BOD
BLANKS	24		8.62	8.25	0.37		0.38
	17		8.61	8.24	0.37		
	5		8.63	8.23	0.4		
2:00 PM	167	20 ml	8.26	5.94		29	29
	2	20 ml	8.29	5.92		30	
	150	20 ml	8.24	5.98		28	
4.00 PM	21	20 ml	8.34	5.84		32	32
	17	20 ml	8.32	5.79		32	
	10	20 ml	8.36	5.82		32	
6.00 PM	9	20 ml	8.23	4.95		44	44
	18	20 ml	8.25	4.97		44	
	14	20 ml	8.26	4.91		45	
8.00 PM	3	20 ml	8.24	5.48		36	36
	4	20 ml	8.25	5.52		35	
	152	20 ml	8.21	5.43		36	
10.00 PM	6	20 ml	8.24	5.84		30	30
	7	20 ml	8.27	5.95		29	
	60	20 ml	8.29	5.97		29	
12.00 AM	11	20 ml	8.31	6.02		29	29
	12	20 ml	8.34	6.04		29	
	13	20 ml	8.35	5.98		30	
4.00 AM	1	20 ml	8.21	6.79		16	15
	4	20 ml	8.19	6.87		14	
	16	20 ml	8.2	6.74		16	
6.00 AM	23	20 ml	8.11	6.78		14	15
	22	20 ml	8.12	6.74		15	
	14	20 ml	8.11	6.71		15	
8.00 AM	12	20 ml	8.09	6.47		19	18
	20	20 ml	8.07	6.57		17	
	3	20 ml	8.08	6.54		17	
10.00 AM	11	20 ml	8.17	6.21		24	23
	19	20 ml	8.15	6.19		24	
	23	20 ml	8.14	6.24		23	
12.00 PM	2	20 ml	8.26	6.15		26	25
	18	20 ml	8.23	6.17		25	
	146	20 ml	8.24	6.19		25	

Biochemical Oxygen Demand Experiment 7 (14/10/04)

Grab Sampling Method

SAMPLE	BOTTLES ID	VOLUME OF SAMPLES	INITIAL D.O	FINAL D.O	BLANK CORRECTION	BOD (mg/l)	AVERAGE BOD
BLANKS	22 168 1		8.75 8.75 8.75	8.16 8.26 8.19	0.59 0.49 0.56		0.5
INFLUENT STP	15 164 20	20 ml 20 ml 20 ml	8.53 8.53 8.53	1.03 1.32 1.35		105 101 100	102
EFFLUENT STP	19 23 17	50 ml 50 ml 50 ml	8.35 8.37 8.32	6.03 6.09 6.08		11 11 10	11

Biochemical Oxygen Demand Experiment 8 (20/10/04)

Composite Sampling Method

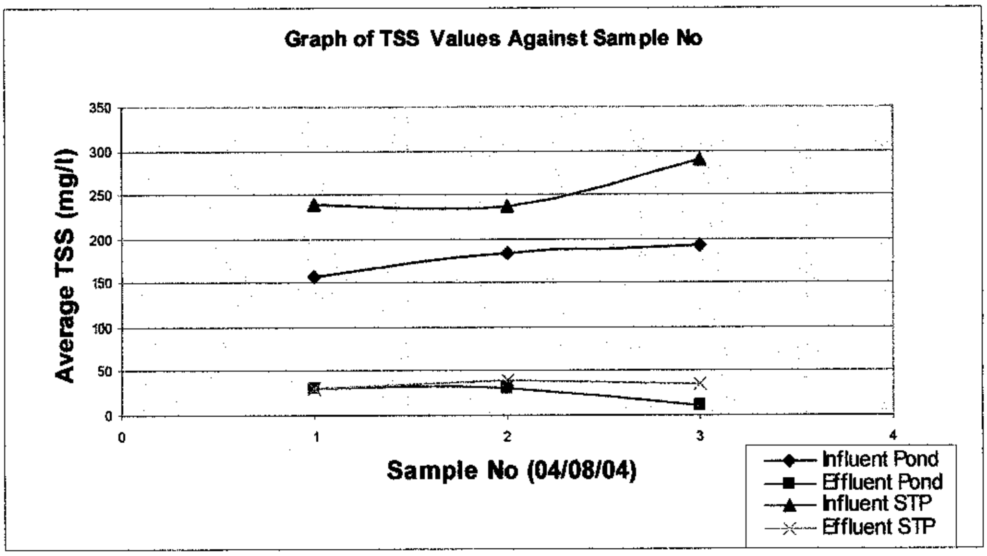
SAMPLE	BOTTLES ID	VOLUME OF SAMPLES	INITIAL D.O	FINAL D.O	BLANK CORRECTION	BOD (mg/l)	AVERAGE BOD
BLANKS	5		8.71	8.39	0.32		
	24		8.66	8.37	0.29		0.3
	8		8.66	8.39	0.27		
	15	20 ml	8.52	6.22		30	
12:00 PM	1	20 ml	8.37	6.69		21	25
	153	20 ml	8.53	6.64		24	
	11	20 ml	8.31	5.69		35	
2.00 PM	2	20 ml	8.3	5.79		33	36
	8	20 ml	8.29	5.28		41	
	12	20 ml	8.3	3.86		62	
4.00 PM	2	20 ml	8.3	4.36		55	55
	9	20 ml	8.31	4.71		50	
	4	20 ml	8.38	6.86		18	
6.00 PM	22	20 ml	8.38	6.85		18	19
	10	20 ml	8.37	6.65		21	
	3	20 ml	8.39	6.85		19	
8.00 PM	15	20 ml	8.41	7.13		15	16
	21	20 ml	8.39	7.02		16	
	101	20 ml	8.27	5.94		30	
10.00 PM	17	20 ml	8.3	6.22		27	28
	6	20 ml	8.27	6.2		27	
	6	20 ml	8.39	7.41		10	
12.00 AM	22	20 ml	8.26	7.25		11	10
	13	20 ml	8.34	7.38		10	
	41	20 ml	8.25	7.11		13	
2.00 AM	46	20 ml	8.24	7.14		12	13
	42	20 ml	8.28	7.09		13	
	30	20 ml	8.24	7.19		11	
4.00 AM	28	20 ml	8.21	7.23		10	11
	14	20 ml	8.25	7.25		11	
	7	20 ml	8.32	6.52		23	
6.00 AM	24	20 ml	8.3	6.56		22	22
	1	20 ml	8.31	6.55		22	
	150	20 ml	8.23	6.21		26	
8.00 AM	146	20 ml	8.26	6.18		27	27
	148	20 ml	8.29	6.15		28	
	17	20 ml	8.29	4.52		52	
10.00 AM	20	20 ml	8.26	4.53		51	52
	18	20 ml	8.24	4.51		51	
	18	20 ml	8.27	6.26		26	
12.00 PM	52	20 ml	8.25	6.22		26	26
	31	20 ml	8.28	6.29		25	

APPENDICES II

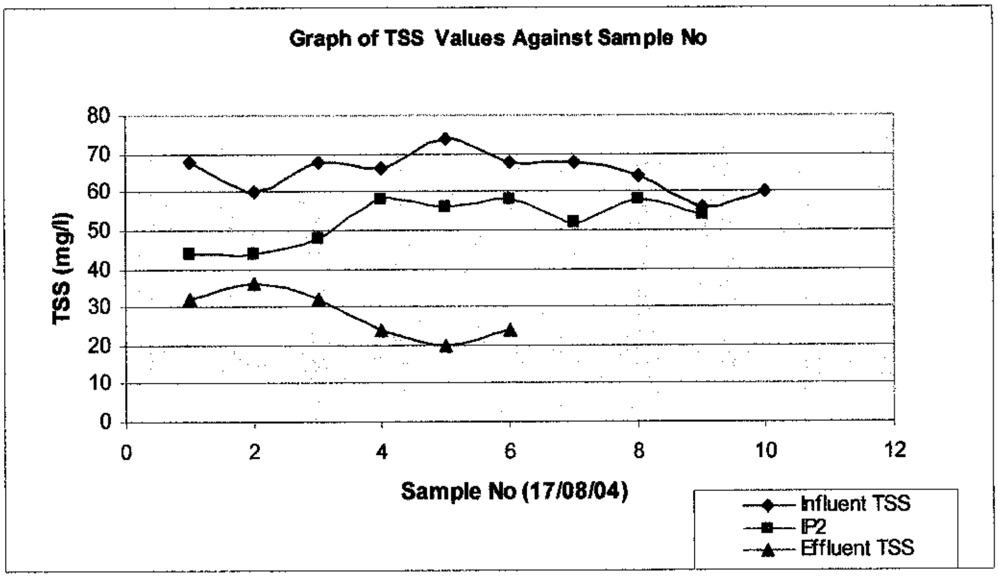
LABORATORY WORK

GRAPHS

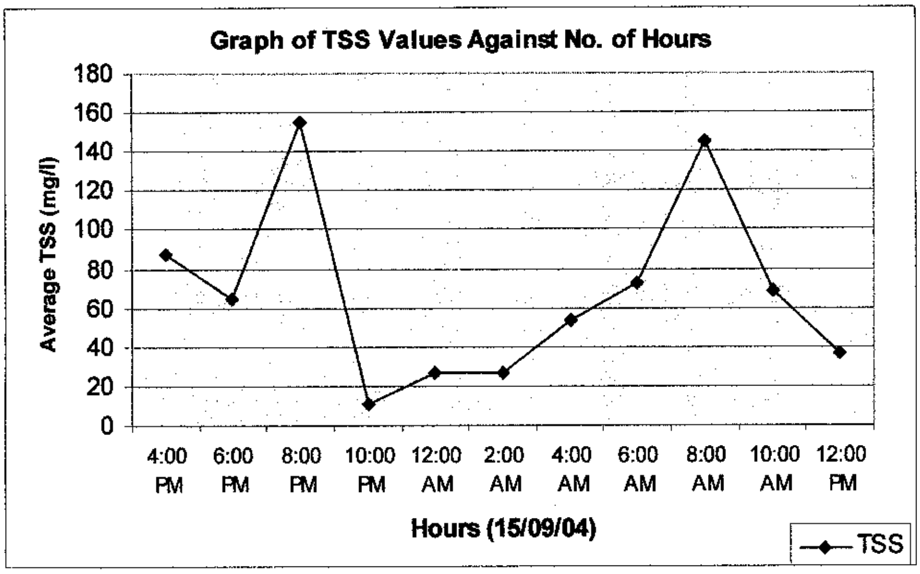
Total Suspended Solids Experiment 1 (04/08/04)



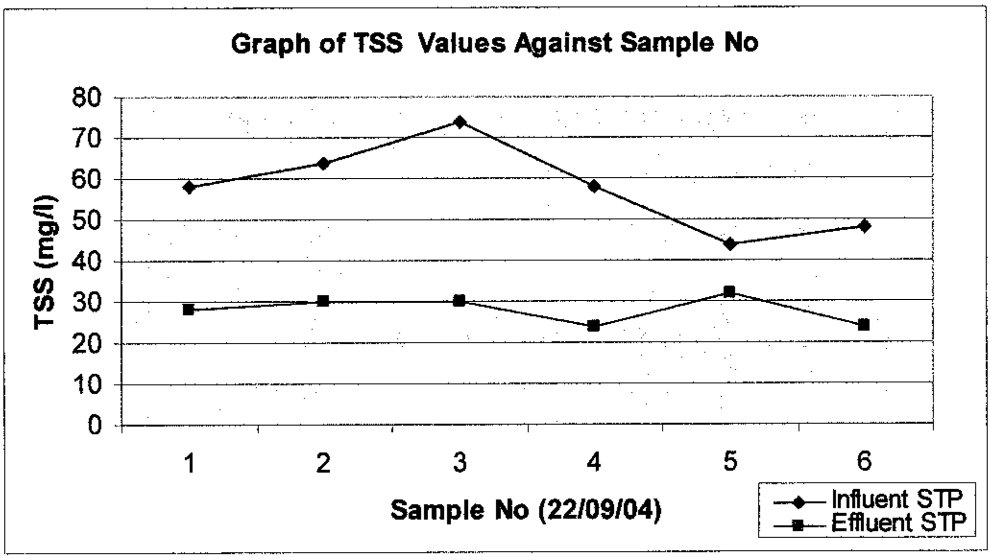
Total Suspended Solids Experiment 2 (17/08/04)



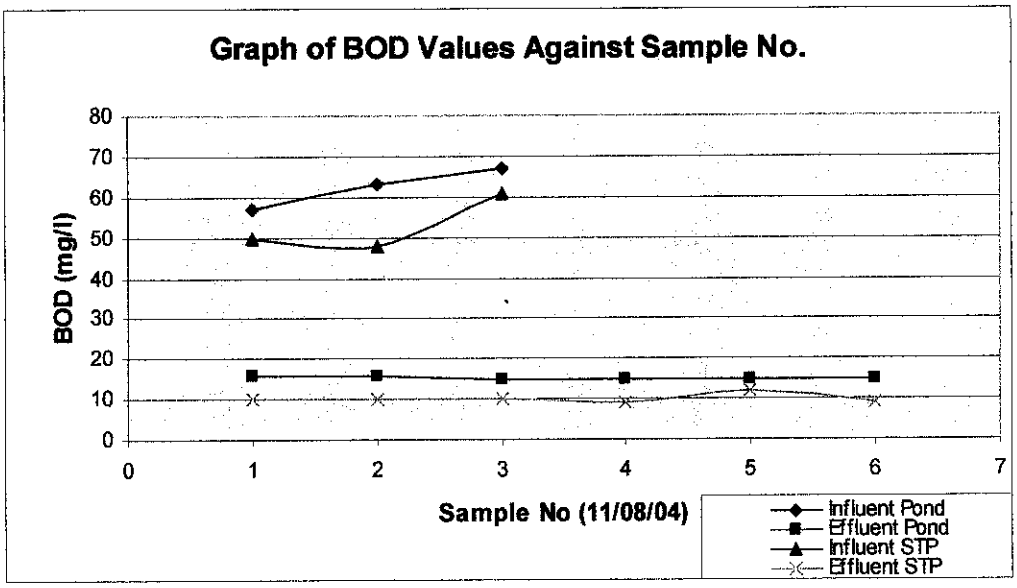
Total Suspended Solids Experiment 3 (15/09/04)



Total Suspended Solids Experiment 4 (22/09/04)



Biochemical Oxygen Demand Experiment 1 (11/08/04)



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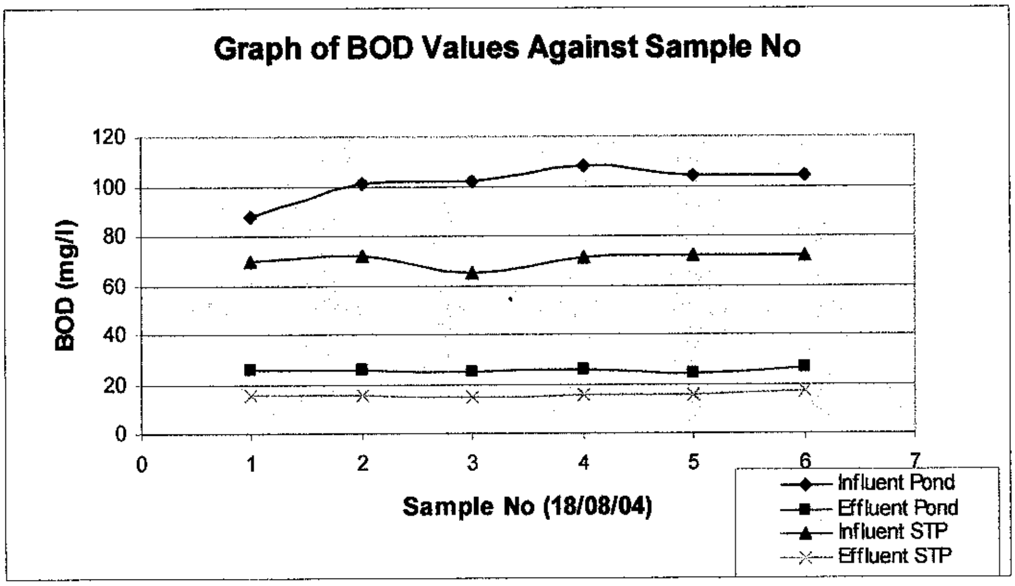
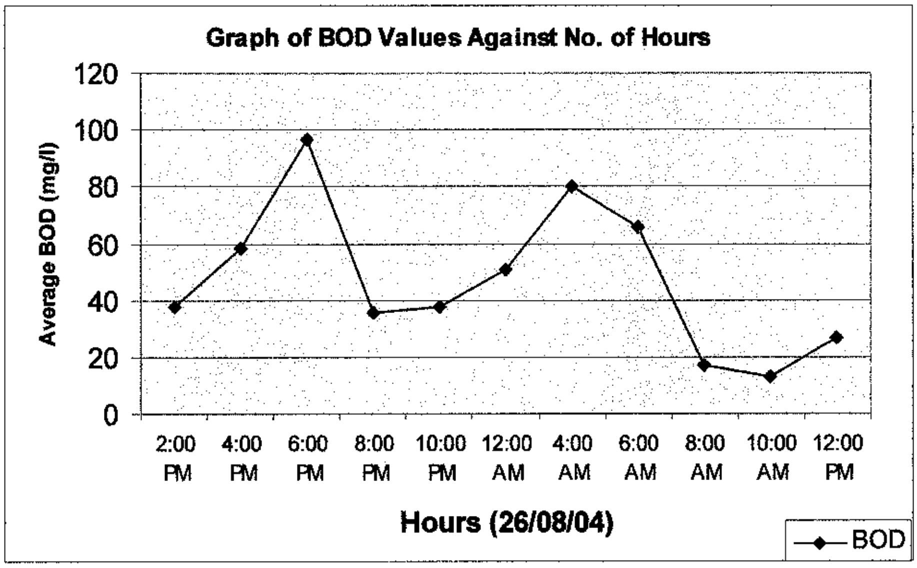
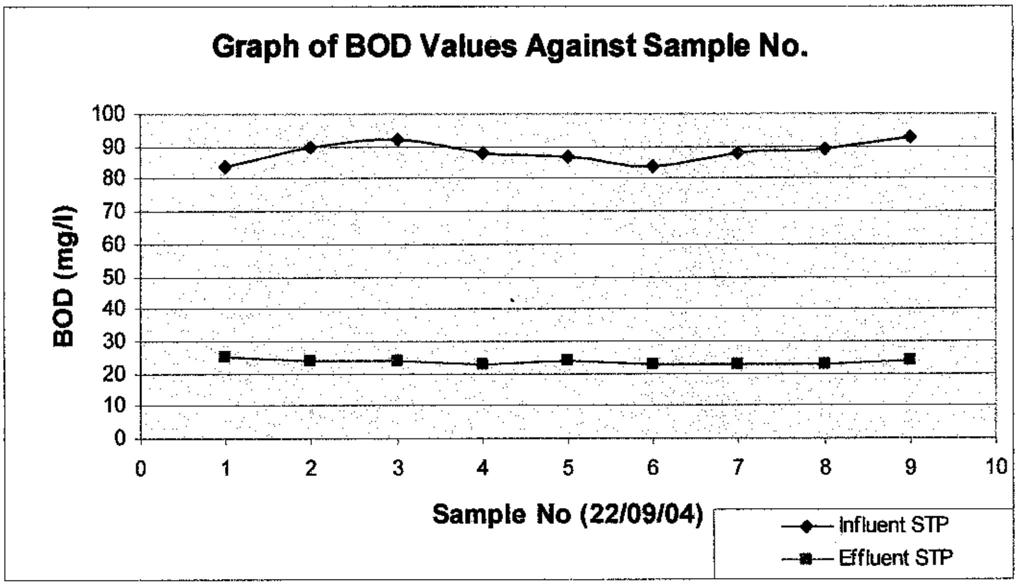


Biochemical Oxygen Demand Experiment 3 (26/08/04)



Biochemical Oxygen Demand Experiment 4 (22/09/04)



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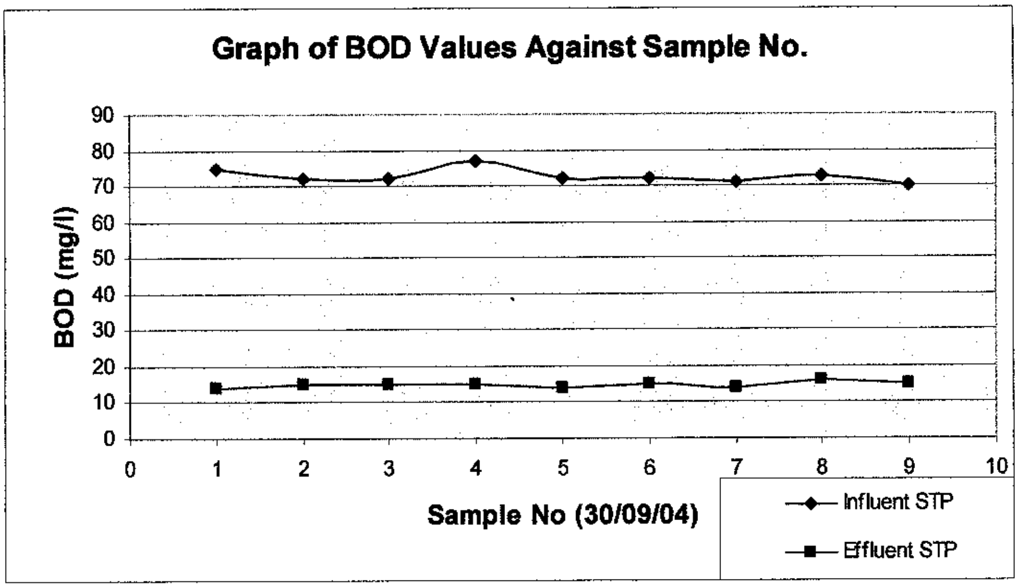

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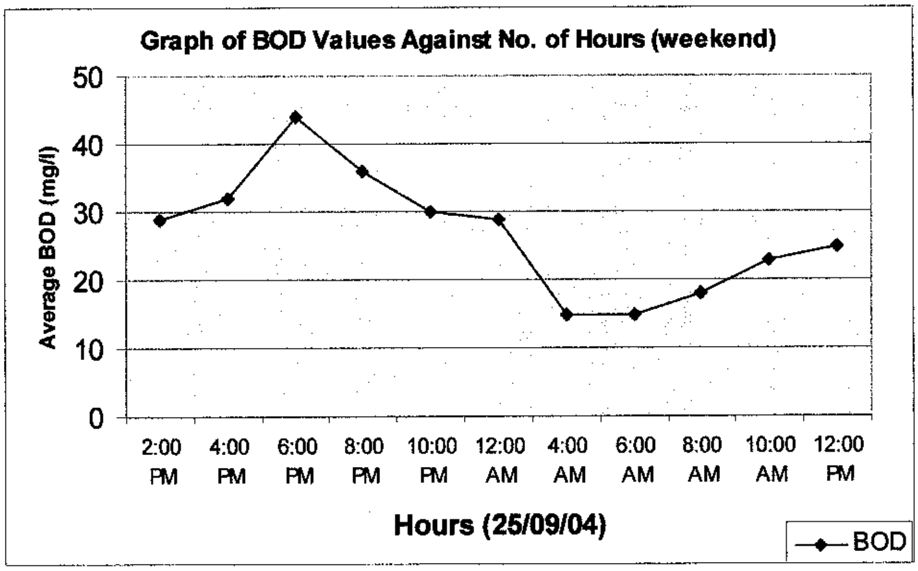
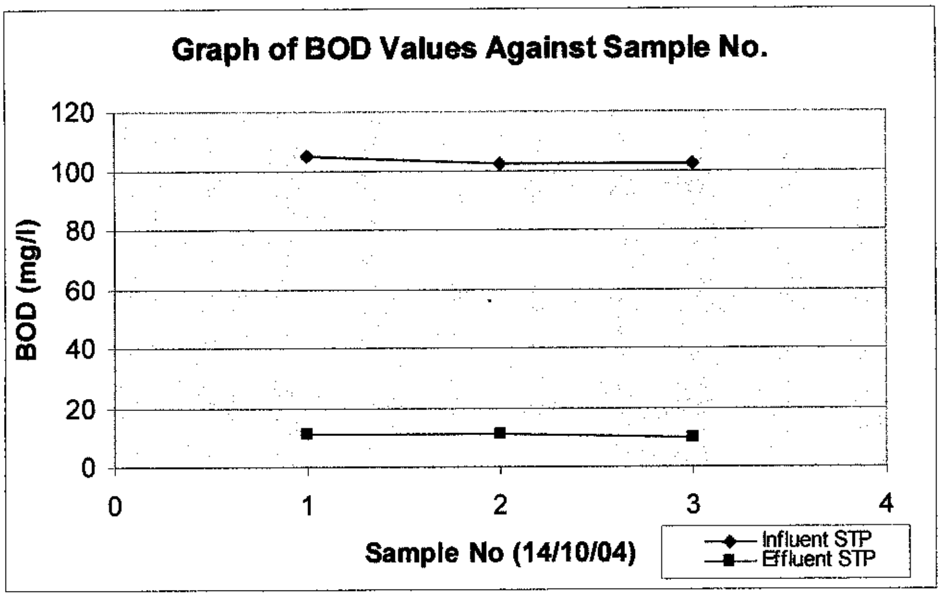
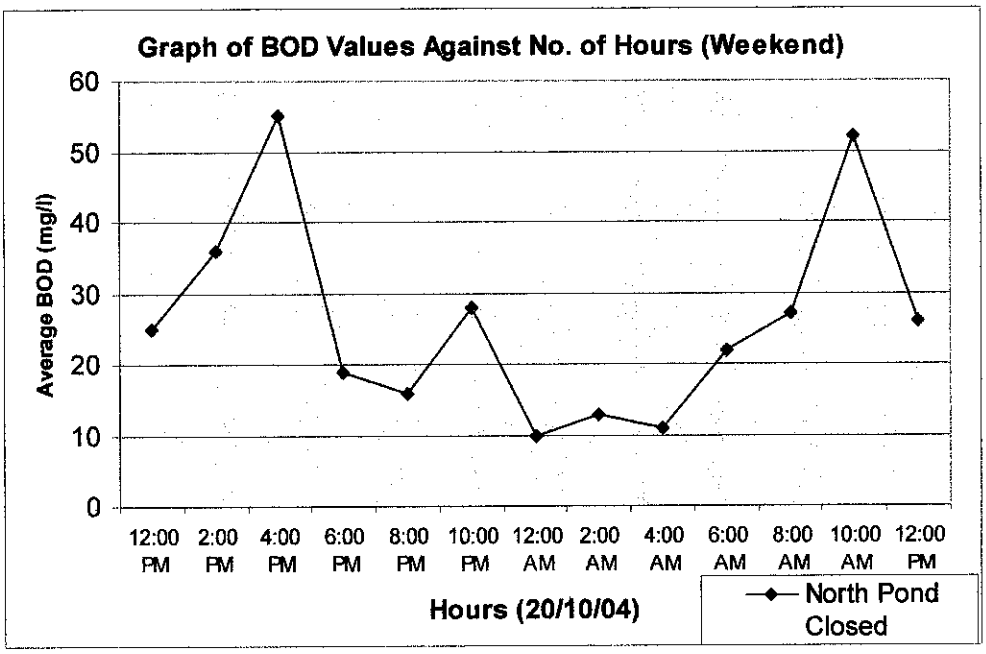


Biochemical Oxygen Demand Experiment 7 (14/10/04)



Biochemical Oxygen Demand Experiment 8 (20/10/04)



APPENDICES III

GANNT CHART

Gantt chart: Individual Milestone for Final Year Project (FYP) Semester January 2004

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Selection of project topic														
2	Preliminary Research Work														
	• Understanding the project awarded														
	• Literature review on TSS & BOD														
	• Project planning														
	• Construct Gantt Chart														
3	Submission of Preliminary Reports					23/2									
4	Project Work														
	• Experimental Work														
5	Submission of Progress Report									19/4					
6	Submission of Interim Report													17/5	2/6
7	Oral Presentation														

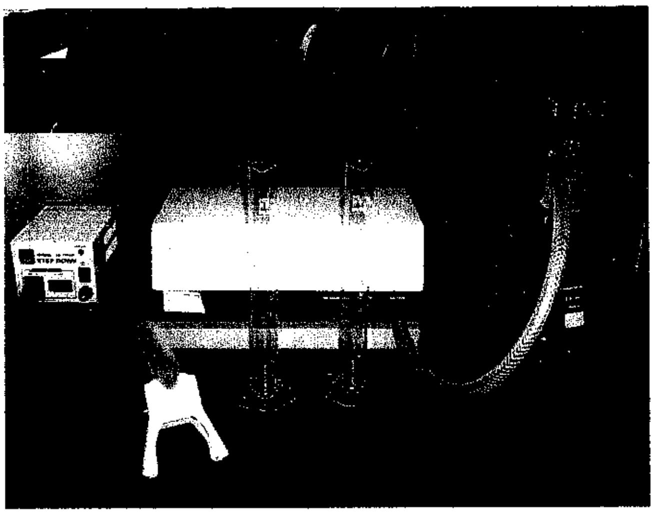
Gantt chart: Individual Milestone for Final Year Project (FYP) Semester July 2004

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Project Work Continues														
2	Experimental Works														
	• Grab Sampling Method														
	• Composite Sampling Method														
	• BOD & TSS analyses														
	• Graph Developing														
3	Submission of Progress Reports						**20/08**				**22/10**				
4	Data Analysis														
5	Oral Presentation													**14/12**	**03/01**
6	Submission of Dissertation														

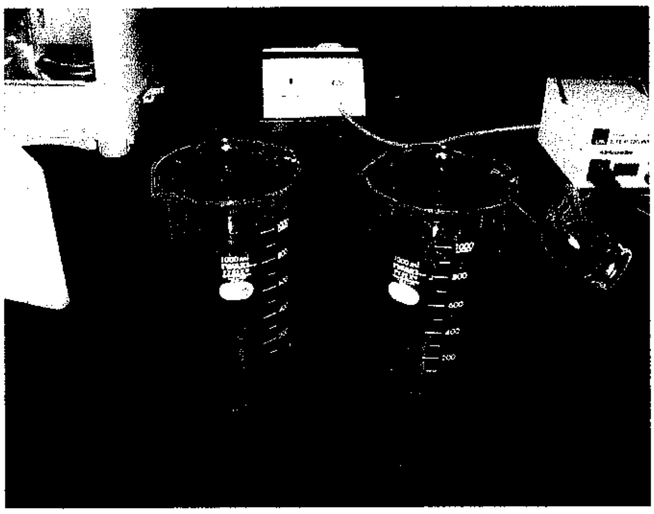
APPENDICES IV

LABORATORY WORK

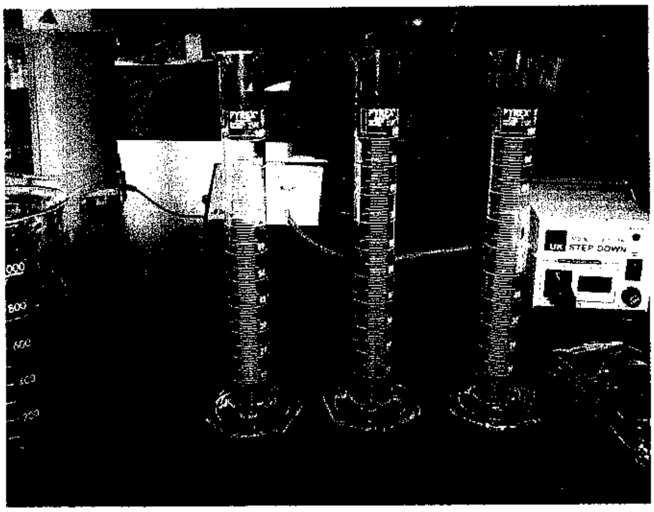
EQUIPMENTS



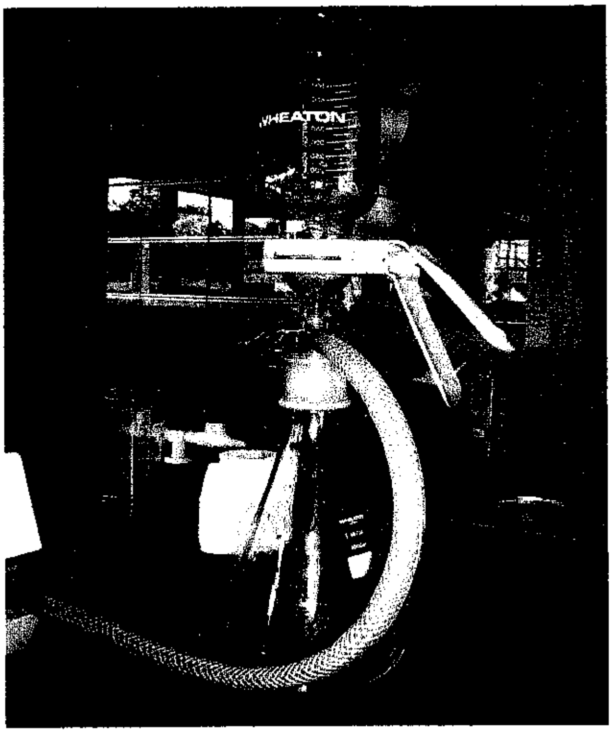
Vacuum Pump for TSS test.



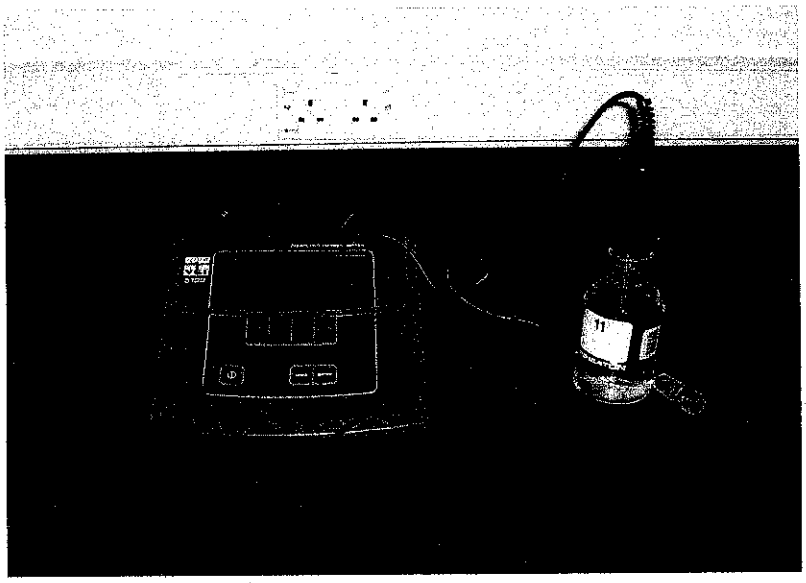
500ml Beaker (TSS)



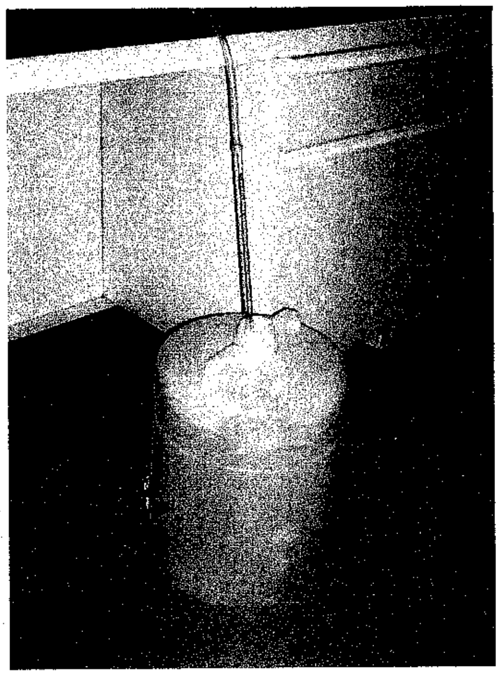
Measurement Cylinders (TSS)



Filtration unit (TSS)



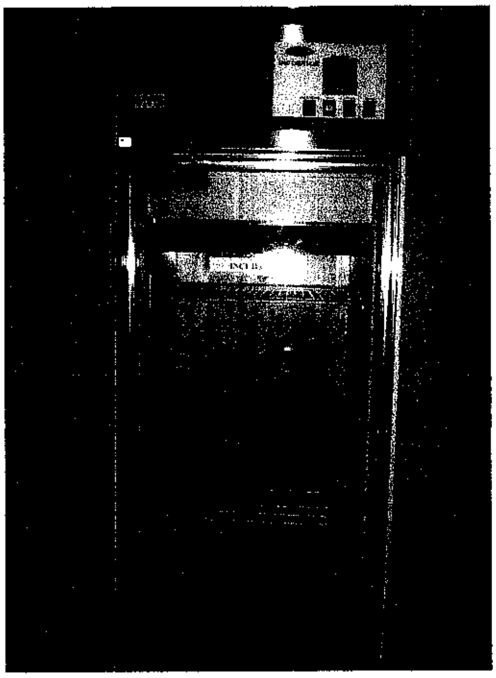
BOD meter / DO probe



Aerated distilled water (BOD)

BOD bottles

Calibration on distilled water (BOD)



Incubator (BOD)

Desiccator (TSS)