Monitoring the Removal of TOC, COD, Oil and Grease & Heavy Metal in UTP Sewage Treatment Plant

by

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6007

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CERTIFICATION OF APPROVAL

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

(Dr. Shamsul Rahman Kutty)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

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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.

SURAYA SABRI AFIFI

ABSTRACT

The activated sludge treatment process is a biological method of wastewater treatment that is performed by variable and mixed community of microorganism in an aerobic aquatic environment. The Universiti Teknologi PETRONAS (UTP) owns a sewage treatment plant (STP) that discharges its waste stream into a small stream. The discharge is permitted by the Department of Environment. The STP was designed to meet effluent limitations of Standard B. The objective of this study is to optimize the UTP's sewage treatment plant to determine and evaluate the sludge age for optimum removal parameters or pollutants such as oil and grease, TOC, COD and also heavy metal such as copper. Some of the sewage treatment plant problems were parts did not function well and were not used; made this system uneconomical, contributing to a very poor quality of treated wastewater of the effluent quality. In optimizing the UTP's sewage treatment plant, the procedure on conducting each experiment such as TOC, COD, oil and grease and heavy metal were different. In the first phase of this study, all samples were taken at the activated sludge treatment system and also an oxidation pond as the activated sludge was closed for rectification works. While in the second phase, the samples were taken at the influent and effluent of the activated sludge treatment plant after the treatment plant were rectified. Samples were taken on different days and weeks to see the characteristics and flow of the wastewater. Results from the experiments in the first phase showed that the values of TOC were higher before the rectification work. In the second phase, the results proved that the values for all experiments were less in compared to the first phase. As for copper, the results showed that there was not much copper contained in the UTP's STP due to its' designed of municipal wastewater. The range of COD removal was around 60% to 80% while for TOC was around 40% to 70%.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

The activated sludge process is one of the most widespread wastewater purification technologies. In this process, wastewater is mixed with a concentrated biomass suspension (the activated sludge) responsible for the degradation of the pollutants. Activated sludge treatment process relates to these three components; a reactor in which microorganism is responsible for treatments which are kept in suspension and aerated, liquid solids separations (sedimentation tank) and a recycle system for returning solids removed from the liquid solids separation unit back to the reactor.

As formerly known, Universiti Teknologi PETRONAS (UTP) sewage treatment plant was initially owned by the University of Science Malaysia. After taking over the campus, UTP inherited this sewage treatment plant. In the beginning, the plant had two stabilization ponds but now it is equipped with a new activated sludge treatment system by UTP. Due to several problems that occurred, the stabilization pond broke down and had not been used anymore. The activated sludge system in UTP is designed to cater a population of 11,500 equivalents and the plant handles and treats which comes from hostels, new and old academic buildings, laboratories, cafes, chancellor hall, library and etc.

Therefore, this study is on the parameters of Universiti Teknologi PETRONAS (UTP), sewage treatment plant. This activated sludge system which is not working properly, will be fully monitored in the upgrading and optimizing of the system.

1.2 PROBLEM STATEMENT

The Sewage Treatment Plant facility is an extended aeration activated sludge system that consists of an inlet/primary screen, equalization tank, pumping station, secondary screens, grit chamber, grease chamber, two aeration tanks in parallel, two secondary clarifier in parallel, chlorine contact tank, Parshall flume, sludge thickener, sludge holding tank, sludge sand drying beds, dewatering facility and an air blower/control room.

As mentioned, the activated sludge system that was used by UTP was not working and functioning well as expected due to several problems. The problems occurred due to lack of well maintenance on the system by the professional engineer. These problems occurred which made the effluent discharge did not met the requirement standard B of Environmental Quality Act, 1979. Solids that settled at the bottom of the grit chamber could not be pushed into the pipes due to the air pushing system that failed to function properly. The leakage at the second aeration tank (showing poor functioning) as well as the non-functioning pump which was operated to suck the sludge showed that the recycling of the sludge to the aeration tank is too poor to work.

1.3 OBJECTIVE OF STUDY

The main objective of this study are to monitor the performance of UTP's sewage treatment plant and to determine and evaluate the sludge age for optimum removal parameters or pollutants such as TOC, COD, oil and grease, and heavy metal (copper). Another objective of this study is to comply with the law and local standard requirements set by the government in reducing contaminated levels to permissible value before discharging it to the public stream.

The activated sludge process design requires determining the amount of sludge productions, the amount of oxygen needed as well as the effluent concentration which are important parameters.

1.4 SCOPE OF STUDY

The scope of this study is to conduct experiments and evaluate the parameters such as TOC, COD, heavy metal (copper) and oil and grease of UTP's activated sludge system in order to monitor the performance of the UTP's sewage treatment plant.

The project is divided into two main phases. Both of the phases concentrate on the determination and investigation of TOC, COD, heavy metal and oil and grease. As the activated sludge system is closed by the UTP's management for about two months for rectifying purposes, the wastewater flows to the stabilization pond. Therefore, in the first phase of the study, it concentrates on the activated sludge treatment system and also the stabilization of the pond. In the second phase, the study mainly focuses on the influent and effluent of activated sludge treatment system.

CHAPTER 2

LITERATURE REVIEW

2.1 Defects of UTP's Sewage Treatment Plant before Rectified Works

The first problem of the sewage treatment plant before being rectified is at the mechanical and manual screen bar (see figure 1), where the inlet to the mechanical screen cannot be completely closed even if the penstock is lowered (see figure 2). The wastewater can not flow smoothly through the inlets to the manual bar screens as its inlet levels are higher than the inlet level for the mechanical bar screen (see also figure 3 and figure 4).

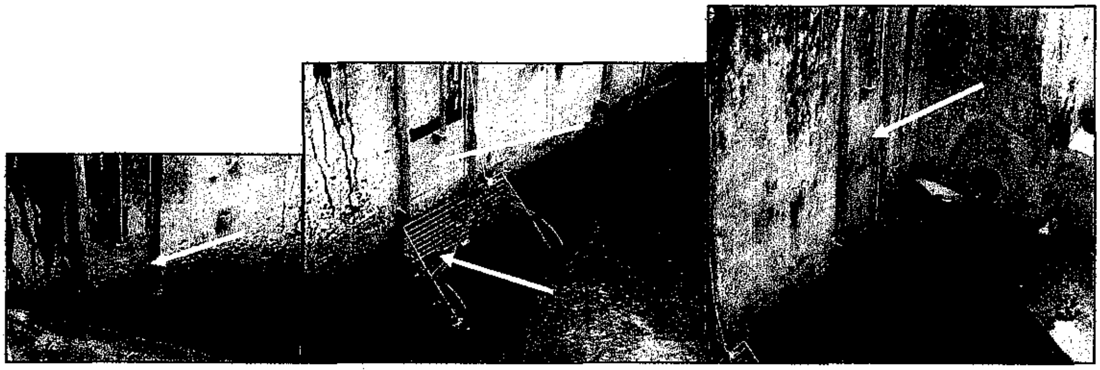

Figure 1. Inlets to Primary Screens (before rectified)

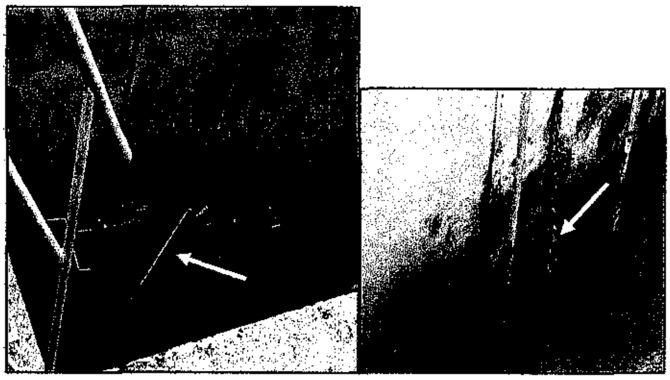

Figure 2. Inlets to Primary Screens (after rectified)

The mechanical screen frequently malfunctions and similar problems were noted in the secondary screening system. The grit chamber had never operated since the operating contractor took over. Investigation discovered that the speed of the turbine may had been too low which allowed most of the organic matter to settle to the bottom of the grit chamber (the speed of the turbine was set) and the system was not able to remove the grit through the grit washing facility. From the grit chamber, the wastewater then flowed into a horizontal oil and grease trap chamber of 6 meters length. The chamber was equipped with a scum skimmer to remove oil and grease.

In the anoxic zone one submersible mixer was installed at an unknown distance from the floor of the chamber at the inlet end of the chamber. The purpose of the mixer was to mix active microorganisms present in the chamber with the raw influent and prevent settling of biomass in the anoxic chamber. Settling of sludge in the anoxic chamber will affect the sludge age and concentration of biomass in the aeration tank.

The aeration tank was never seeded during startup of the plant. It was important that, the hydraulic detention time should be adhered to prevent washing out of biomass into the clarifier. Two secondary clarifiers were provided but only one was in operation.

The operation of the sludge recycle pumps was very crucial in maintaining sludge recycle rates and sludge wastage rates. However, the sludge scrapper and the motor drive unit were found to be defective. The clarifier also, had the potential to short-circuit to the effluent weir due to the flow of the wastewater (refer figure 5). Hence, most of the parts of the activated sludge system which was installed in UTP had not been used before and some of the parts which had been used did not work properly and needed to be repaired. (R.Shamsul, 2005)

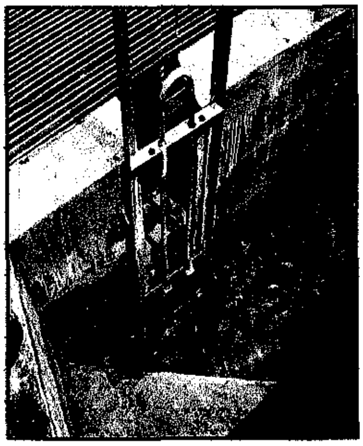

Figure 3. Manual screen bars (before rectified)

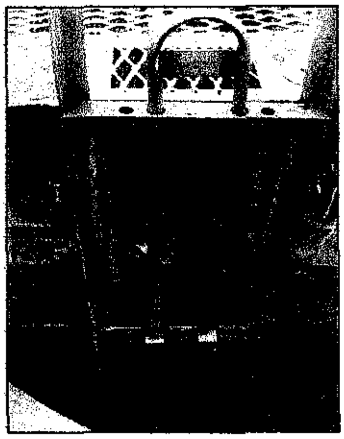

Figure 4. Manual screen bars (during rectification)

Figure 5. Short circuit of flow

2.2 Description of parameters involved

2.2.1 Total Organic Carbon

The activated sludge process was now used routinely for biological treatment of municipal and industrial wastewaters (Metcalf and Eddy, 1994). With greater frequency, activated sludge processes used today may incorporate nitrification, biological nitrogen removal and biological phosphorus removal (Metcalf and Eddy, 1994). TOC was the amount of carbon bound in organic compounds. Often used as an indicator of water quality or cleanliness of pharmaceutical manufacturing equipment (Droste, 1997). Total organic carbon (TOC) tests are based on oxidation of the carbon of the organic matter to carbon dioxide and determination of CO2 either by absorption in KOH or instrumental analysis (infrared analyzer) (Romalho, 1983). Efficient removal of organic carbon substances can be achieved without any problem in most activated sludge plants, and numerous respirometric techniques have been developed for detailed monitoring of organic carbon removal in activated sludge (Gernaey, Bogaert, Vanrolleghem, 1998).

Measuring organic and inorganic carbons on the surface and inside ground waters is of great interest to assess quality of life in many ecosystems. In pollution abatement works, organic carbon measurement provides a quick and simple method for monitoring pollution levels as well as the accumulation of non biodegradable or refractory organic materials. Under the ecological point of view, organic and inorganic carbon measurements give quantitative information about the carbon cycle and productivity of natural bodies of water. In environmental engineering, measurement of organic carbon provides a non-specific measure for monitoring potentially toxic organic materials in natural waters (Fardini, Jardim, Guimardes, 2004).

For control of the biological processes in a treatment plant, it is necessary to have some knowledge of the organic strength, or organic load, of the influent wastewater. Three different measures of this are available, and they each have their merits and weaknesses. The Total Organic Carbon (TOC) is analytically straightforward to measure. It involves oxidation by combustion at very high temperatures and measurement of the resultant CO2. However, TOC values include those stable organic carbon compounds that cannot break down biologically (Davies, 2005).

A typical analysis for TOC measures both the total carbon (TC) present as well as the inorganic carbon (IC, or carbonate). There is a need to subtract the inorganic carbon from the total carbon yield TOC. Another common variant of TOC analysis involves removing the IC portion first and then measuring the leftover carbon. This method involves purging the acidified sample with carbon-free air prior to measurement, and so are more accurately called non-purge able organic carbon (NPOC).Virtually all TOC analyzers measure the CO2 formed when organic carbon is oxidized and/or when inorganic carbon is acidified. Oxidation is performed through Pt-catalyzed combustion or with a UV/per sulfate reactor. Once the CO2 is formed, it is measured by a detector: either a conductivity cell (if the CO2 is aqueous) or a non-dispersive infrared cell (if the CO2 is gaseous). Conductivity is only desirable in the lower ranges, whereas NDIR detection excels in the higher ranges. Modern TOC instruments are capable of detecting carbon concentrations as low as 50 µg/L (Droste, 1997).

The reason organic carbon detection is more desired is because of the environmental effects it poses. Chemical plants can only release so much organic carbon per year. Organic carbon readily binds with other elements in the water and air to form harmful compounds. TOC is also of interest in the field of water treatment due to disinfection byproducts formed in chlorination and ozonation reactions. Inorganic carbon poses little to no threat (Droste, 1997).

2.2.2 Chemical Oxygen Demand

Chemical Oxygen Demand (COD) is defined as the quantity of a specified oxidant that reacts with a sample under controlled conditions. The quantity of oxidant consumed is expressed in terms of its oxygen equivalence (Hanna, *Laboratory Instrument*). COD is often measured as a rapid indicator of organic pollutant in water. It is normally measured in both municipal and industrial wastewater treatment plants and gives an indication of the efficiency of the treatment process. COD is measured on both influent and effluent water (Hanna, *Laboratory Instrument*). The efficiency of the treatment process is normally expressed as COD Removal, measured as a percentage of the organic matter purified during the cycle. COD is a defined test; digestion time, reagent strength and sample COD concentration all affect the extent of sample oxidation. COD is often used as a measurement of pollutants in natural and waste waters and to assess the strength of waste such as sewage and industrial effluent waters. COD has further applications in power plant operations, chemical manufacturing, commercial laundries, pulp & paper mills, environmental studies and general education. In potable drinking water plants, COD values should be less than 10 mg/L 02 at the end of the treatment cycle (Hanna, *Laboratory Instrument*).

2.2.3 Relationship between TOC with COD

Since theoretical oxygen demand (ThOD) measures O2 and theoretical organic carbon (ThOC) measures carbon, the ratio of ThOD to ThOC is readily calculated from the stoichiometry of the oxidation equation (Romalho, 1983).

Equation 2.1.1 corresponds to total oxidation of sucrose:-

$$[\mathrm{C\ 12\ H\ 22\ O\ 11}] + [\mathrm{12\ O2} + \mathrm{12\ CO2}] + [\mathrm{11\ H2O}]$$

Molecular weight: $(12 \times 12) \quad (12 \times 32)$

$$\therefore \mathrm{ThOD} / \mathrm{ThOC} = (12 \times 32) / (12 \times 12) = 2.67$$

The molecular weight of oxygen to carbon is 2.67. Thus, the theoretical ratio oxygen demand to organic carbon correspond stoichiometric ratio of oxygen to carbon for total oxidation of the organic compound under consideration. The actual ratio obtained from COD (or BOD) tests and TOC determination varies considerably from theoretical ratio (Romalho, 1983).

Table 2.1: Relationship between Oxygen Demand and Total Carbon for Organic Carbon Compounds

Substance	ThOD:ThOC	COD:TOC
Sucrose	2.67	2.44
Ethanol	4.00	3.35
Methanol	4.00	3.89

Droste, 1997

Organic carbon in water and wastewater are composed of a variety of organic compounds in various oxidation states. Some can be oxidized further by chemical or biological processes, and the chemical oxygen demand (COD) and biological oxygen demand (BOD) methods can be used to characterize these fractions. While, Total Organic Carbon (TOC) is more convenient and direct expression of total organic content than COD or BOD, it does not provide the same kind of information. If a repeatable relationship can be established between TOC and COD or BOD, then TOC can be used as an estimate for COD or BOD for a specific source of water. The correlations must be established independently for each set of conditions including various points in the treatment process. Since TOC is independent of the oxidation state of the organic matter and does not measure inorganic or organically bound matter that can contribute to COD or BOD, TOC measurement cannot take the place of COD or BOD testing (Hanna, *Laboratory Instrument*).

Table 2.2: Comparison of ratios of various parameters used to characterize wastewater

Type of Wastewater	BOD/COD mg/L Average	BOD/TOC mg/L Average
Untreated	0.55	1.6
After primary settling	0.5	1.0
Final Effluent	0.2	0.35

Metcalf & Eddy, 1994

Sometimes removal rates of specific compounds are examined such as nitrate or components that are toxic. The removal rates of nonspecific measures COD, BOD, and TOC will be different. Organics become more oxidized as biological treatment progresses but there is an accumulation of byproducts of microbial growth and metabolism that are difficult to degrade. This is reflected in the ratio of BOD and COD to TOC shown in table 2.3 (Droste, 1997).

Table 2.3: Organic Variation in Treatment of Municipal Wastewater

	BOD mg/L		COD mg/L		TOC mg/L		COD/TOC mg/L	
	Ave	Range	Ave	Range	Ave	Range	Ave	Range
Raw	86	72-105	236	136-304	56	41-70	4.16	3.32-4.68
Primary Effluent	58	46-68	264	146-299	52	44-61	3.9	3.19-5.85
Final Effluent	15	11-20	84	77-95	35	33-40	2.4	2.02-2.58
Average Removal	83		64		32			

Droste, 1997

Table 2.4: Parameter limits of effluent by Environmental Quality Act 1974

ENVIRONMENTAL QUALITY ACT 1974 (ENVIRONMENTAL
QUALITY (SEWAGE AND INDUSTRIAL EFFLUENTS)
REGULATIONS 1978
[Regulation 8 (1), 8 (2), 8 (3)]
PARAMETER LIMITS OF EFFLUENT OF STANDARDS A AND B

Parameter	Unit	Standard	
		A	B
Temperature	C	40	40
pH Value		6.0 - 9.0	5.5 - 9.0
BODs at 20°C	mg/1	20	50
COD	mg/1	50	100
Suspended Solids	mg/1	50	100
Mercury	mg/1	0.005	0.005
Cadmium	mg/1	0.01	0.02
Chromium, Hexavaient	mg/1	0.05	0.05
Arsenic	mg/1	0.05	0.10
Cyanide	mg/1	0.05	0.10
Lead	mg/1	0.10	0.5
Chromium, Trivalent	mg/1	0.20	1.0
Copper	mg/1	0.20	1.0
Manganese	mg/1	0.20	1.0
Nickel	mg/1	0.20	1.0
Tin	mg/1	0.20	1.0
Zinc	mg/1	1.0	1.0
Borom	mg/1	1.0	4.0
Iron (Fe)	mg/1	1.0	5.0
Phenol	mg/1	0.001	1.0
Free Chlorine	mg/1	1.0	2.0
Sulphide	mg/1	0.50	0.50
Oil and Grease	mg/1	Not Detectable	10.0

2.2.4 Heavy Metals in Wastewater

Metals are important in the treatment, reuse and also disposal of treated effluents. Municipal wastewater may contain heavy metals, which are hazardous to the environment and humans, which may be toxic when present in elevated concentrations (Metcalf & Eddy, 1994). Composted sludge is applied in agricultural applications, all kinds of heavy metal such as arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc need to ascertain (Metcalf & Eddy, 1994). With stringent regulations concerning water reuse and sludge utilization in agriculture, there is a great need to determine levels of heavy metals in liquid wastes, sludge and agricultural crops (Al Enezi G, Hamoda MF, Fawzi N, 2004).

Because high rate of wastewater is often applied to the land, there is concern about the presence of high levels of certain trace elements called 'heavy metals'. This group of elements include cadmium, zinc, nickel, copper, chromium, lead, mercury, and others. These components usually occur in small amounts and are not harmful to plants. Some heavy metals, including zinc and copper, are micronutrients which are necessary for plant growth. Excessive amounts of some heavy metals (zinc, copper, nickel) can be damaging to plants, resulting in reduced yield or even plant death (E.Hairston, Stribling, 1995).

Trace quantities of many metals, such as cadmium, chromium, copper, zinc, iron, lead, manganese, mercury and nickel are important constituents of most waters. These metals are necessary for growth of biological life and absence of sufficient quantities of them could limit the growth the algae, but the presence of any of these metals in excessive way and quantities may interfere with the beneficial uses of water due to their toxicity (Metcalf & Eddy, 1994).

Table 2.5: Potential Contaminants in Wastewater

Contaminant	Concern
Pathogens (bacteria and virus diseases)	Human health.
Nitrates	Application in excess of plant needs; excess application entering groundwater.
Organics (chlorinated hydrocarbon pesticides)	Health hazard if directly ingested by animals.
Heavy metals:	
Copper, zinc, and nickel	Accumulation in topsoil; toxic to plants at high levels.
Cadmium	Accumulation in topsoil; taken up by plant and accumulates in leafy material; accumulates in animal organs; human health.
Lead	Accumulation in topsoil; potentially harmful if excessive amounts are ingested with soil particles by animals.
Mercury, chromium, selenium,	Little concern unless present in extremely high amounts.

Source: Muse, Mitchell, and Mulens 1991.

Table 2.6: Metals of importance in wastewater management

Cocentration treshold of inhibitory effect on heterotrophic organism	Metal
0.05 mg/L	arsenic
1.0 mg/L	cadmium
10.0 mg/L	chromium
1.0 mg/L	copper
0.1 mg/L	lead
0.01 mg/L	mercury
1.0 mg/L	nickel
1.0 mg/L	zinc

Crites and Tchobanoglous, 1998

2.2.5 Oil and Grease

The term oil and grease, as commonly used, includes the fats, oils, waxes and other related constituents found in wastewater. The term fats, oil and grease (FOG) used previously had been replaced by the term oil and grease. The oil and grease content of wastewater was determined by extraction of the waste sample with trichlorotrifluoroethane. Oil and grease were quite similar chemically; compounds (esters) of alcohol or glycerol with fatty acids. The fatty acids that are liquid at ordinary temperatures are called oils, and those that are solids are called grease (Metcalf & Eddy, 1994).

The presence of high strength oil and grease (O&G) in industrial wastewaters poses serious challenges for biological treatment systems, often necessitating costly modifications by inclusion of physio-chemical processes such as flotation, sedimentation, flocculation and membrane filtration. In aerobic systems, high oil and grease has a detrimental impact on oxygen transfer efficiency (Gurlois, Arlic, Poroclion, 1993).

Fats and oils are essentially triglycerides consisting of straight-chain fatty acids attached, as esters, to glycerol. The component fatty acids of edible fats and oils vary considerably. They can differ in chain length, may be saturated or unsaturated, and may contain an odd or even number of carbon atoms. The term 'grease', as commonly used, includes fats, oils, waxes and other related constituents found in wastewater (Wakelin, Forster, 1996).

The fatty acid composition of the effluent grease will depend on the menu of foods being cooked, and the types of cooking fats and oils used in the kitchens. Despite the existence of diverse products, such as grease traps and biological/nutrient supplements, available to cafes and restaurants for tackling grease-related problems, none was considered by the restaurant managers to deliver an adequate performance. This would suggest that the operators of conventional grease-traps and those using biological/nutrient supplements should be highly receptive to any commercial development of microbial cultures for use in a bioreactor for the treatment (Wakelin, Forster, 1996).

If grease was not removed before discharge of treated wastewater, it can interfere with the biological life in the surface waters and create unsightly films. The thickness of oil required to form a translucent film on the surface of a water body was about 0.0003084 mm (Metcalf & Eddy, 1994).

Table 2.7: Thickness of oil required to form a translucent film on surface

Appearance	Film Thickness	
	in	mm
Barely visible	0.0000015	0.0000381
Silvery sheen	0.0000030	0.0000762
First trace of color	0.0000060	0.0001524
Bright bands of color	0.0000120	0.0003048

Eldridge, 1942

CHAPTER 3

METHODOLOGY

For this study of monitoring UTP's sewage treatment plant, several methods were used and laboratory experiments were conducted. Laboratory experiments needed to evaluate the removal efficiency of Total Organic Carbon (TOC), Chemical Oxygen Demand (COD), oil and grease and heavy metal (copper).

In the first phase of this study, the samples were previously taken from the UTP's activated sludge treatment system before it was closed for rectified works. Subsequently, some samples were also taken from the oxidation pond for experiments of TOC and heavy metals. These samples were taken on a different days to obtained the characteristic of the wastewater.

In the second phase of the study, the samples were mainly taken at the influent and effluent of the activated sludge treatment system. In addition, there were two kinds of monitoring methods that are being executed. The first way of monitoring was by taking samples for 24 hours at the influent of the activated sludge system to evaluate the characteristic. While the second monitoring was by carrying out the 'grab sampling' method. Both of this monitoring were required to conduct experiments to obtain the output. In second phase of this study, experiments were performed for TOC, COD, oil and grease, and also heavy metal (copper).

3.1 Total Organic Carbon Measurement

For optimizing and upgrading UTP's Sewage Treatment Plant, the texperiments on TOC is carried out using the Total Organic Carbon Direct Method High Range Test 'N Tube™ Reagent Set with DRB200 Reactor.

The total organic carbon (TOC) determined by first sparging the sample under slightly acidic conditions to remove the inorganic carbon. At the outside of the vial, organic carbon in the sample is digested by per sulfate and acid to form carbon dioxide. During digestion, the carbon dioxide diffuses into a pH indicator reagent in the inner ampule. The adsorption of carbon dioxide into the indicator forms carbonic acid. Carbonic acid changes the pH of the indicator solution which, in turn, changes the color. The amount of color change is related to the original amount of carbon present in the sample.

The first step of this procedure is switching the reactor to the heat of 102 - 105°C. The heater or reactor that is used is to obtain fast organic reactions with specific temperature and vessel requirements (refer figure 6). Since it is vital that the reaction take place at 105°C (±2°C) for 2 hours, it is important to ensure accurate pre-heating. The reactor must also be equipped with a timer to notify the operator when the reaction is completed. It is necessary to use a graduated cylinder to add 10mL of the sample to 50mL flask and 0.4mL of Buffer Solution into the flask (refer figure 7). Next, place the flask on a stir plate and stir the plate at a moderate speed for 10 minutes to amalgamate the samples with the buffer solution. Vials sample and reagent blank need to be added with TOC Persulfate Powder Pillow to each Acid Digestion vial. Continue by adding 0.3mL of the sample into the sample vial and 0.3mL of distilled water into the reagent blank vial. Rinse two blue Indicator Ampules with distilled water (refer figure 8) and wipe it with a soft, lint free wipe. The next step is lowering an unopened ampule into each Acid Digestion vial. Snap the top off the ampule and allow it to drop into the Acid Digestion vial. Cap the vial assemblies tightly and place them in the reactor. After 2 hours, remove the vials carefully and allow it to cool for one hour. Subsequently, the readings need to be recorded (refer figure 9).

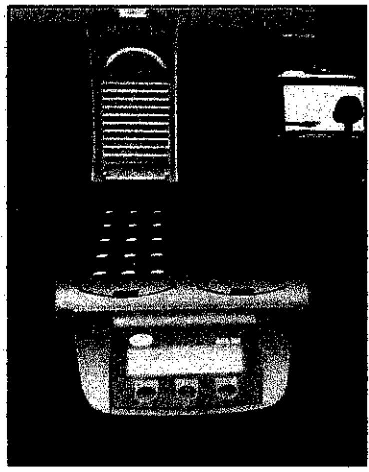

Figure 6. Reactor

Figure 7. 0.4mL Buffer Solution to add in sample

Figure 8. Two Blue Indicator being rinsed

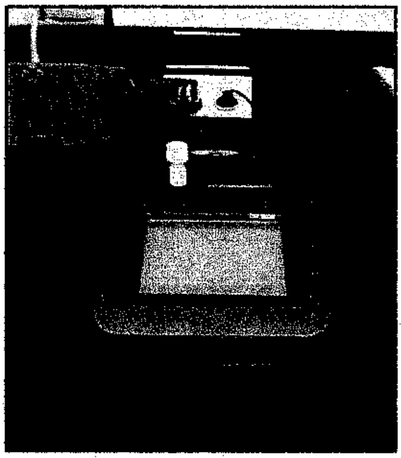

Figure 9. Readings were recorded

3.2 Chemical Oxygen Demand Measurement

The amount of oxygen is important in oxidizing an organic compound (biodegradable and non-biodegradable) to CO2 and water under the strong oxidant in an acid environment. The major advantage of this test is that it requires a shorter time which is approximately 3 hours.

Similar to the procedure of TOC, it is necessary to switch on the reactor and heat it to 150°C. The reactor is used to obtain fast organic reactions with specific temperature and vessel requirements. Since it is vital that the reaction takes place at 150°C for 2 hours, it is important to ensure accurate pre-heating. The heat that is produced indicates an exothermic process occurred. The reactor is also equipped with a timer to notify the operator when the reaction is completed. 2 ml of the sample is measured and poured into a test tube which contains potassium dichromate. Next, shake the test tube which contained sample and potassium dichromate evenly. Then, place the test tube together with a blank sample as an indicator into the reactor for 2 hours. Record the readings right after the test tube cool off.

3.3 Heavy Metals – Copper Measurement

The procedures for the copper experiment are entirely different from the TOC and COD experiment. The first step is to prepare two sample cells. Each of the sample cells needs to be filled with 10mL of sample. The first sample cell needs to be added with the content of CuVer® 1 Copper Reagent Powder Pillow. For a sample of a prepared sample, refer to figure 10. Twirl the sample cell which contains both the sample and reagent that are mixed well. Leave the sample cell for 2 minutes. Right after the time expires, put a second sample cell with 10 mL of sample as the blank sample. Then, note down the reading of the sample by inserting the blank into the cell holder, followed by the sample cell with the reagent and sample (refer figure 11).

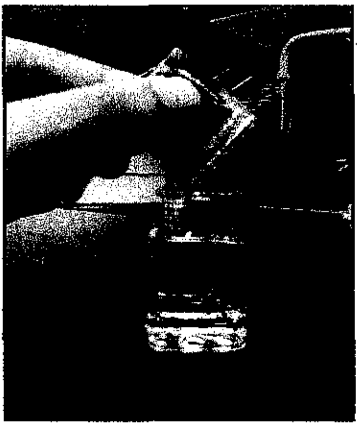

Figure 10. Added Copper Reagent Powder to sample

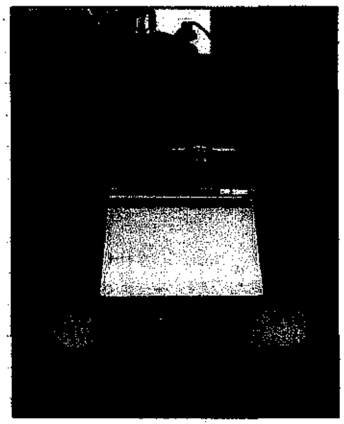

Figure 11. Readings were recorded

3.4 Oil and Grease Measurement

Oil and grease are extracted from samples using tetracholoethylene (C2C4). It is then measured quantitatively by a non-dispersive infrared (NDIR) method. Oil and grease have IR absorption at 3.5um wavelength which is due to the stretching of the C-H bond of hydrocarbon. The amount of absorption at 3.5um wavelength is proportionate to the content of oil and grease extracted from the sample.

The oil and grease are measured by using a NIC Model Oil-20A Content Meter. This machine needs to warm up approximately 20 minutes after switching it on for stabilization purposes. After 20 minutes, rinse the machine with 10mL of C2CI4 three times. The control knob must indicate MEAS at the position of 0.00 reading and the control knob of CALIB needs to be adjusted until it displays a value of 7.8 p.p.m. Next, turn the control knob back to MEAS and make sure that it still shows the 0.00 values before recording any reading. Transfer samples of 50mL and 10mL of C2CI4 into a separate funnel. Shake vigorously for about 1 minute and leave the funnel for 15 minutes. The content in the funnel is separated into two layers. The top layer should be the sample and the bottom layer should be C2CI4, containing the extracted oil. Drain the bottom C2CI4 into a conical flask to take the measurement.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 1st PHASE OF THE STUDY: BEFORE RECTIFICATION

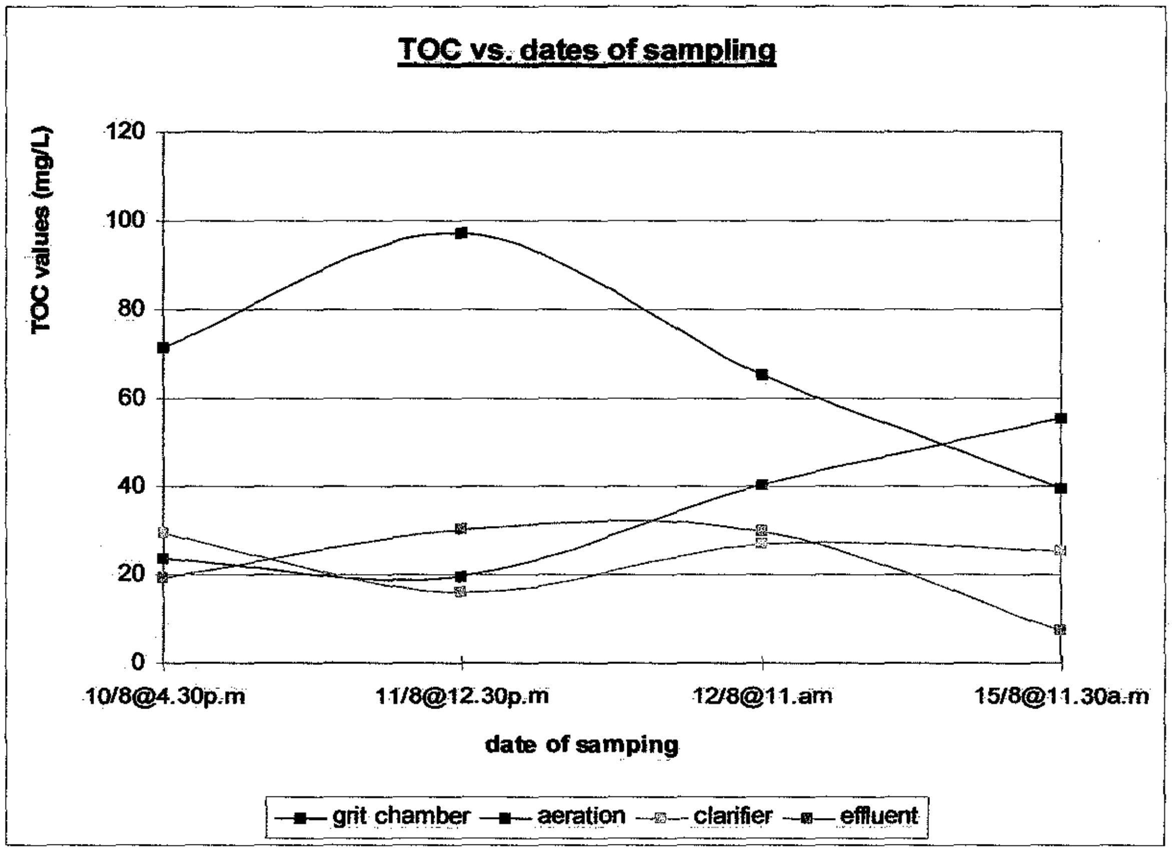

Figure 12. TOC vs. date of sampling (10-15/8/2006)

The activated sludge treatment plant was closed for rectification works on 16th August, 2006. Due to the short notice, only 4 experiments were performed using sample taken from the activated sludge treatment plant before it was closed. From figure 12, it showed that the amount of TOC in the aeration tank and clarifier was considered low at the beginning but increased on 12th and 15th August, 2006. This low amount of TOC in the aeration tank was related to the amount of MLSS in the aeration tank which also had low values that did not even reach up to 250 mg/L (refer figure 13). Another reason for these high values of TOC and TSS on the 15th August, 2006 was that the rectification work had started at the time before it was closed formally.

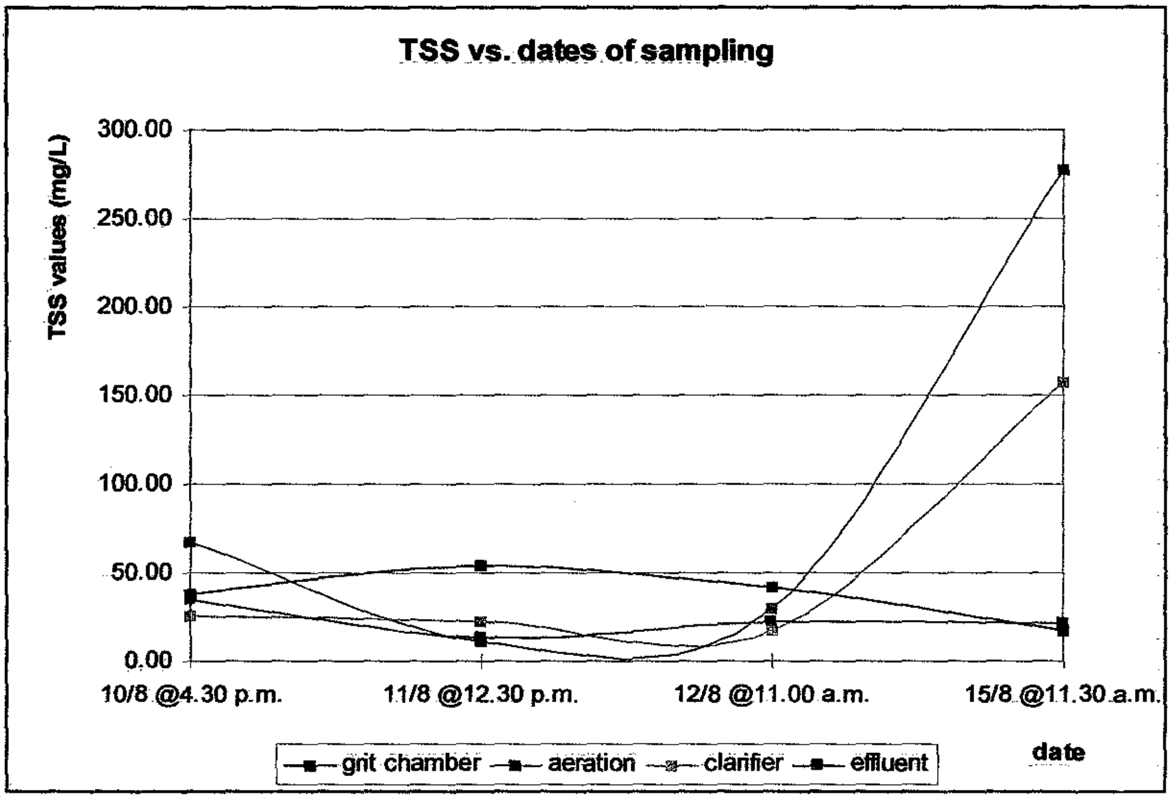

Figure 13. TSS vs. date of sampling (10-15/8/2006)

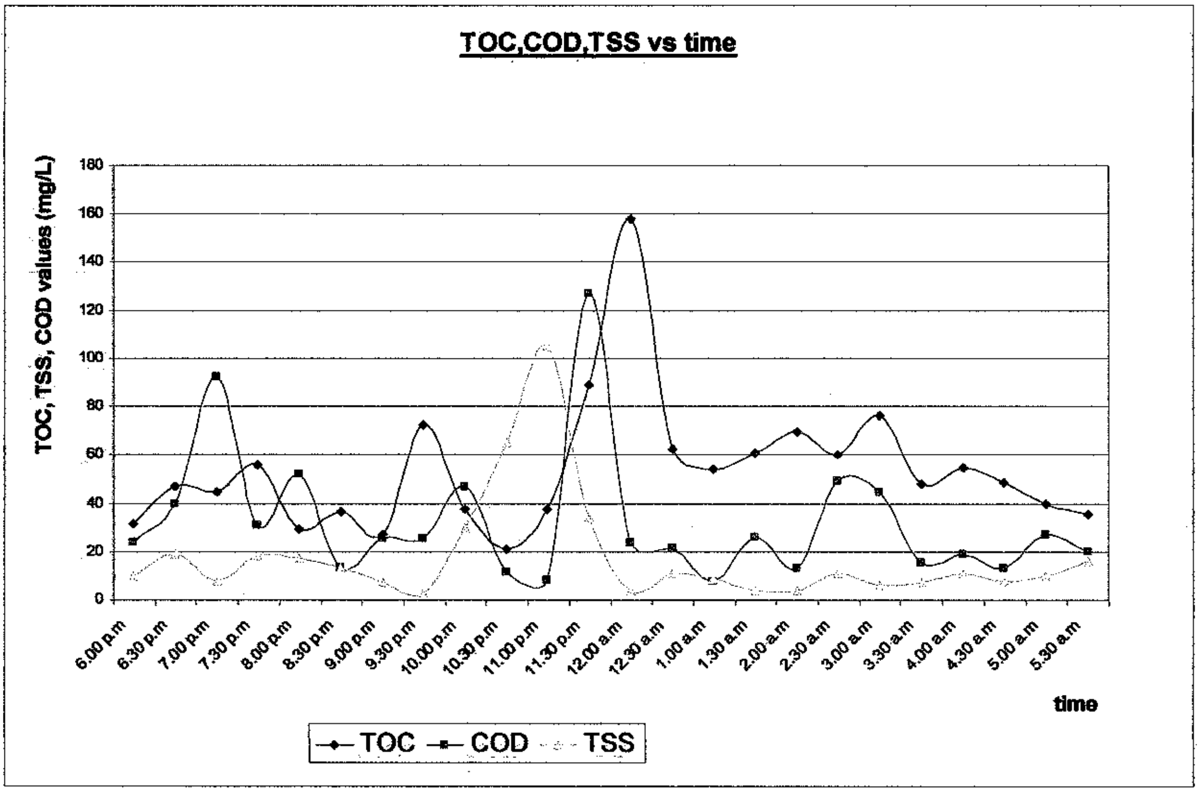

Figure 14. TOC, COD, and TSS vs. times of day (19th September 2006)

After the sewage treatment plant closed, the experiments were performed using samples taken from the influent of the stabilization pond. All of the wastewater ended up flowing into the stabilization pond due to the rectification worked. Figure 14 showed that the experiments were performed using 12 hours samples on Tuesday, 6.00 p.m to Wednesday 5.30 a.m (19th September 2006). The result of this experiment showed that around 11.00 p.m to 1.00 a.m the values of TOC, COD and TSS were high because of the treats that came from the cafes, which were closed at night and also the use of chemicals (refer figure 14). However, in the morning and evening, the values became low. This condition occurred probably due to the activities in the morning and evening that were less compared to those at night. As mentioned earlier the STP handled treats from the cafes, library, old and new academic building, hostel and etc.

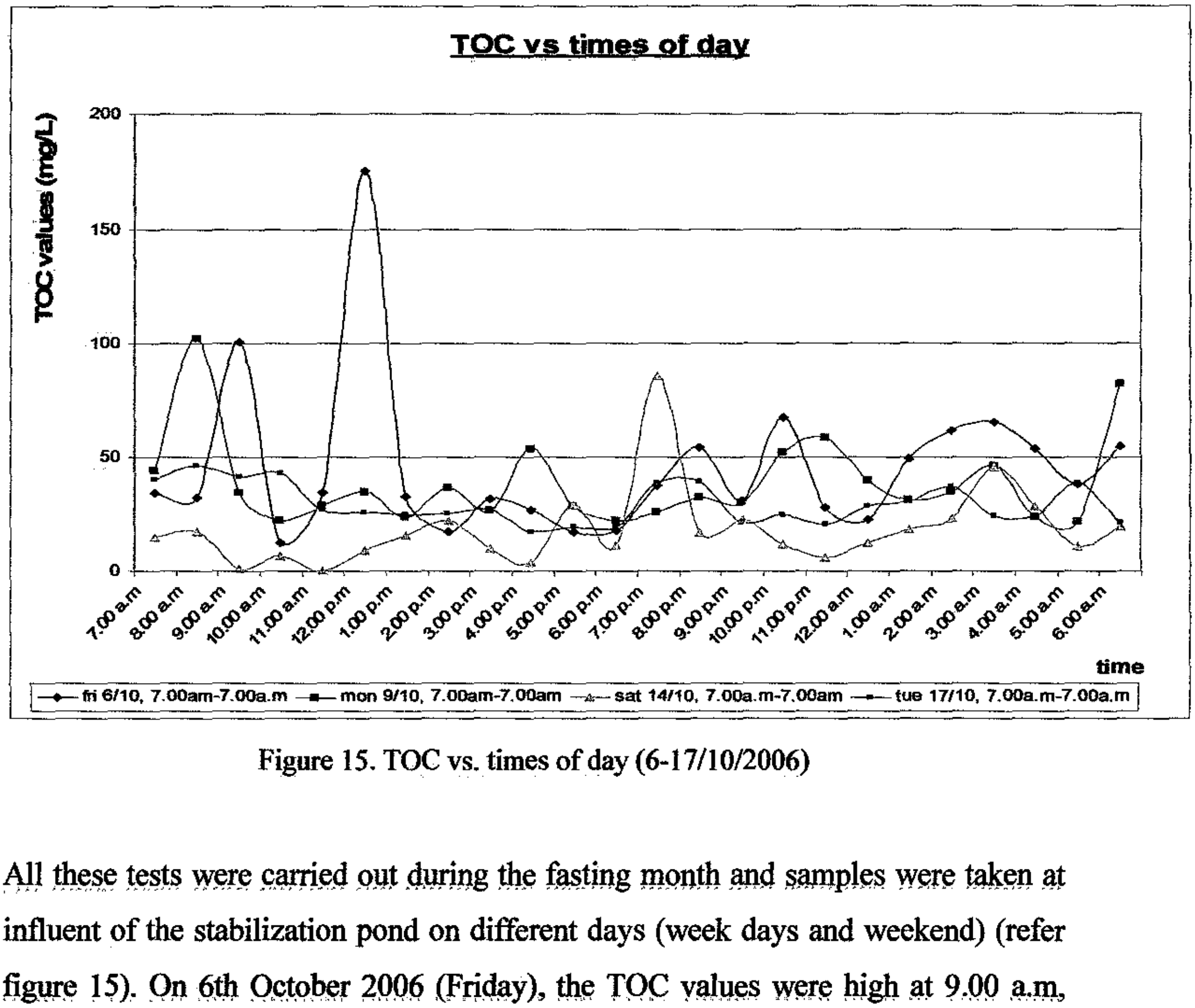

Figure 15. TOC vs. times of day (6-17/10/2006)

All these tests were carried out during the fasting month and samples were taken at influent of the stabilization pond on different days (week days and weekend) (refer figure 15). On 6th October 2006 (Friday), the TOC values were high at 9.00 a.m, 12.00 p.m, 7.00 p.m, and also from 2.00 a.m to 4.00 a.m. The TOC value was high around 9.00 a.m; probably due to students that have just woken up and were preparing themselves for classes. It was also high during noon because of Friday prayers. Just after breaking fast, the values of TOC were much similar as the samples taken before the fasting month. Between 2.00 a.m to 4.00 a.m, the values again raised up highly, due to the students probably taking their 'sahur' meal. Statistical analysis were carried out to see the difference on 6th to 17th October 2006 and since tst = 3.4, 2.3, 3.8, 2.2 > tcr = 2.01, therefore there are significant difference for the TOC results between 6th and 14th, 6th and 17th, 9th and 14th, 9th and 17th of October 2006 at 5% level of significant. Figure 15 also shows that high values of TOC occurring on the 9th, 14th, and 17th October 2006 between 1.00a.m to 2.00a.m. It is concluded that during this month, the TOC values were high around

7.00 p.m to 4.00 a.m. In addition, it showed that on Saturday, 14th October 2006, the TOC values were quite low in compared to other days. This was probably because most of the students went out during the weekend and only came back late in the evening. Figure 16 below shows that the amount of TSS values on Saturday, 14th October 2006, varied from other days as well. The amount of TSS value was rather high during the afternoon on that particular day, which was probably due to laundry washing, cleaning purposes as well as road construction that was in progress at V4 hostels. These circumstances led to different observations for TOC and TSS values on Saturday, 14th October 2006, possibly because only a partial of wastewater flowed into the activated sludge treatment, as the system did not fully operate after the rectification works. Only on the 17th October 2006, the sample was taken at the grit chamber as the system was already in full operation. Results illustrated that, the amount of TOC values were much lesser than those after the rectification works of the activated sludge treatment system.

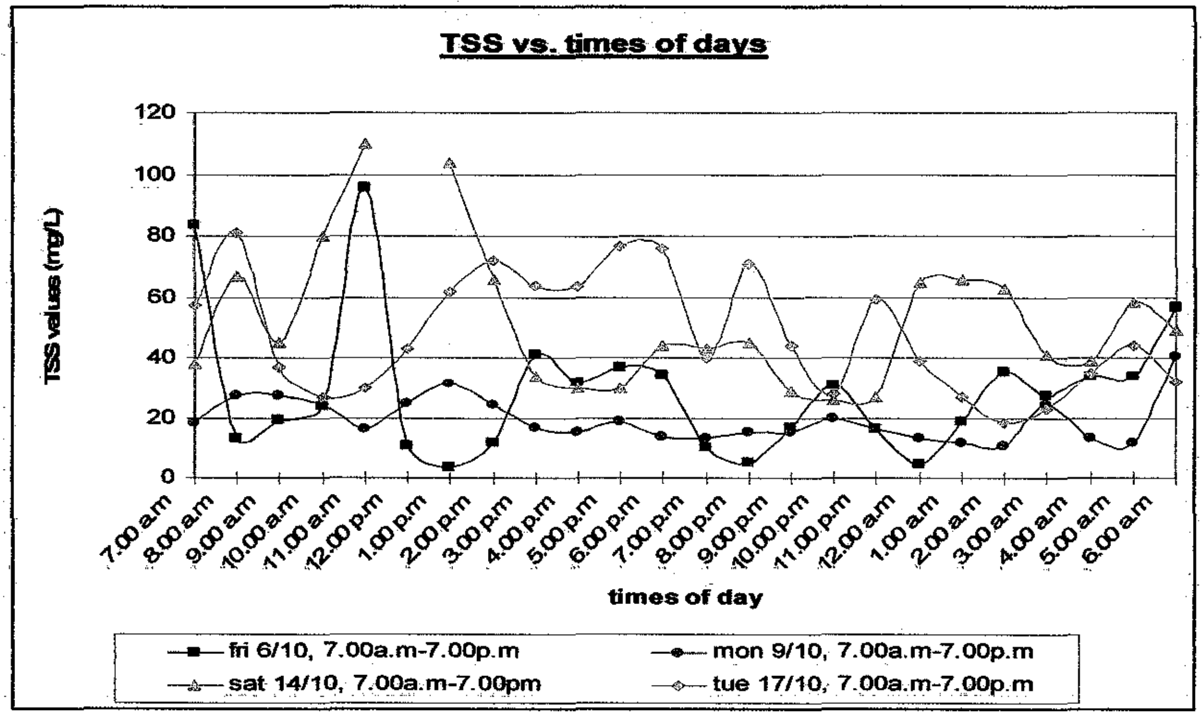

Figure 16. TSS vs. times of day (6-17/10/2006)

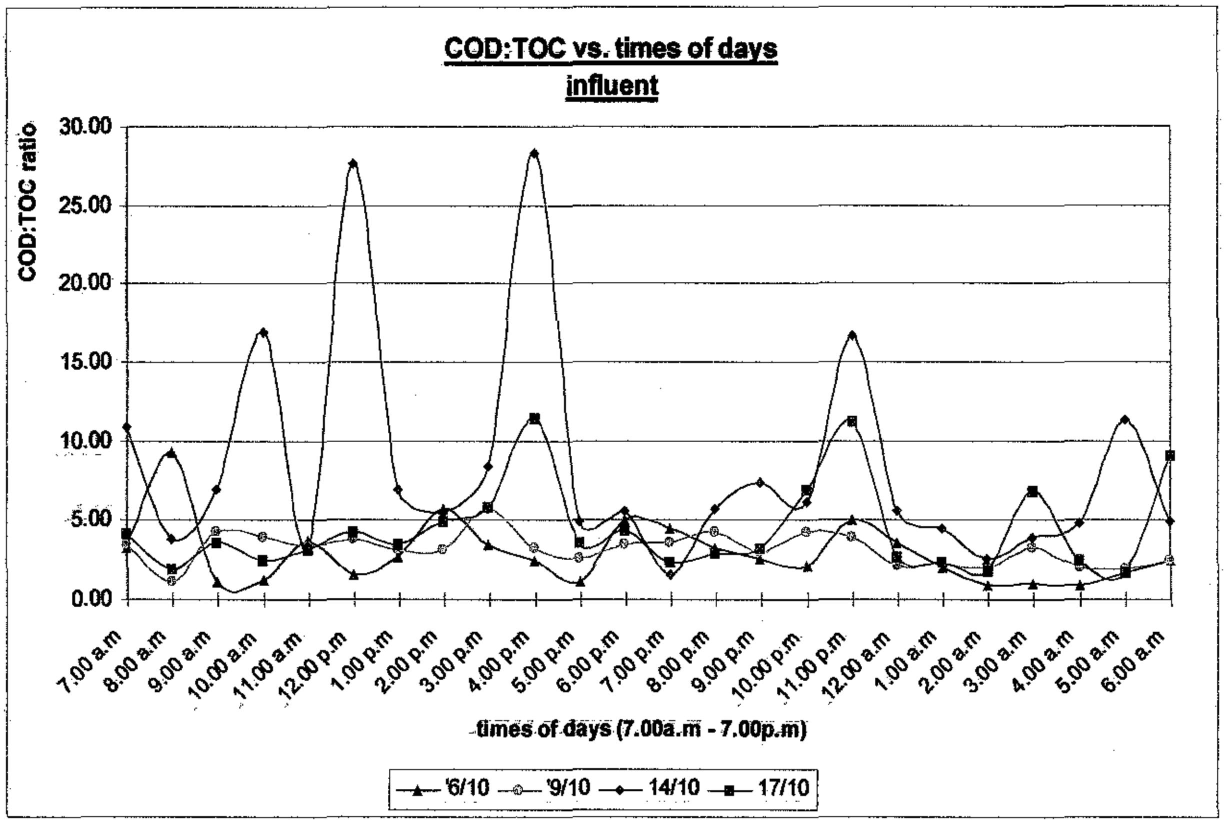

Figure 17. COD:TOC vs. times of day (6/10/2006-17/10/2006)

Figure 17 refers to the ratio of COD:TOC values. As mentioned in the previous chapter, the first phase of this study was done by collecting samples at the influent of the UTP's STP. Hence, the results from the COD:TOC ratio which formed the graph above mostly were out of range if correlated to Table 2.3 (Organic variations in wastewater), because the standard average of COD:TOC ratio for untreated wastewater was around 4.16mg/L. The results for all four days were not steady especially on 14th October 2006, where the ratio reached up to 28.4mg/L. Continuous monitoring action is needed to achieve the objective of this study and also efficient progress of the sewage treatment plant.

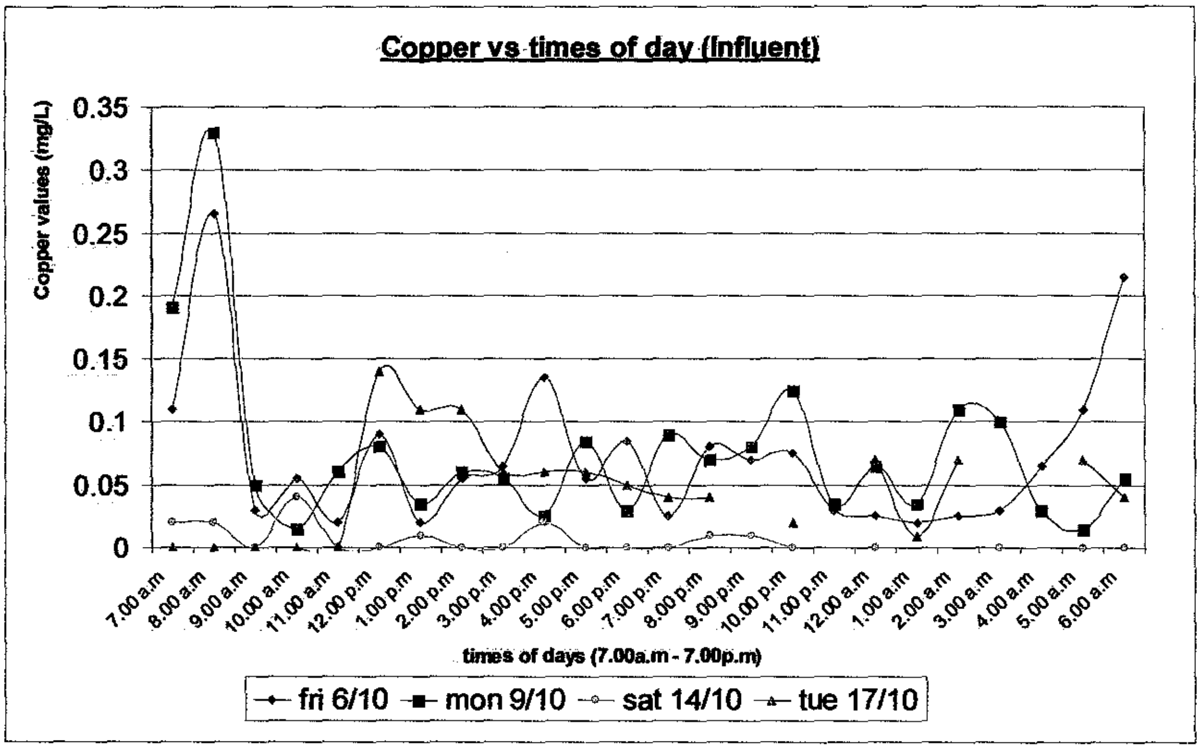

Figure 18. Copper vs. times of day (6-17/10/2006)

Figure 18 shows the presence of heavy metal in UTP sewage treatment plant occurred even at an early stage. The amounts of copper in the wastewater were rather high as results showed 0.25 – 0.35 mg/L throughout 6th October – 9th October 2006. As the time passed by, the values decreased and were almost equal every day and the results from the test showed that less amount of copper occurred. The amount of these copper was lesser when the activated sludge treatment system was operated back on 16th October 2006. These were proven by the result on Tuesday, 17th October 2006, which the sample was taken at the activated sludge treatment system. In addition, some of the copper values were missing due to negative values, which were notified that of no amount of copper was present at that time. The amount of these copper in UTP's activated sludge treatment was under the limit and observation determined that no extensive heavy metal removal should be required for the influent the value does not exceed limits for biological treatment (refer to Table 2.6: Metals of importance in wastewater management). This implies an acceptable value and is not hazardous to aquatic life.

4.1.2 2nd PHASE OF THE STUDY: AFTER RECTIFICATION

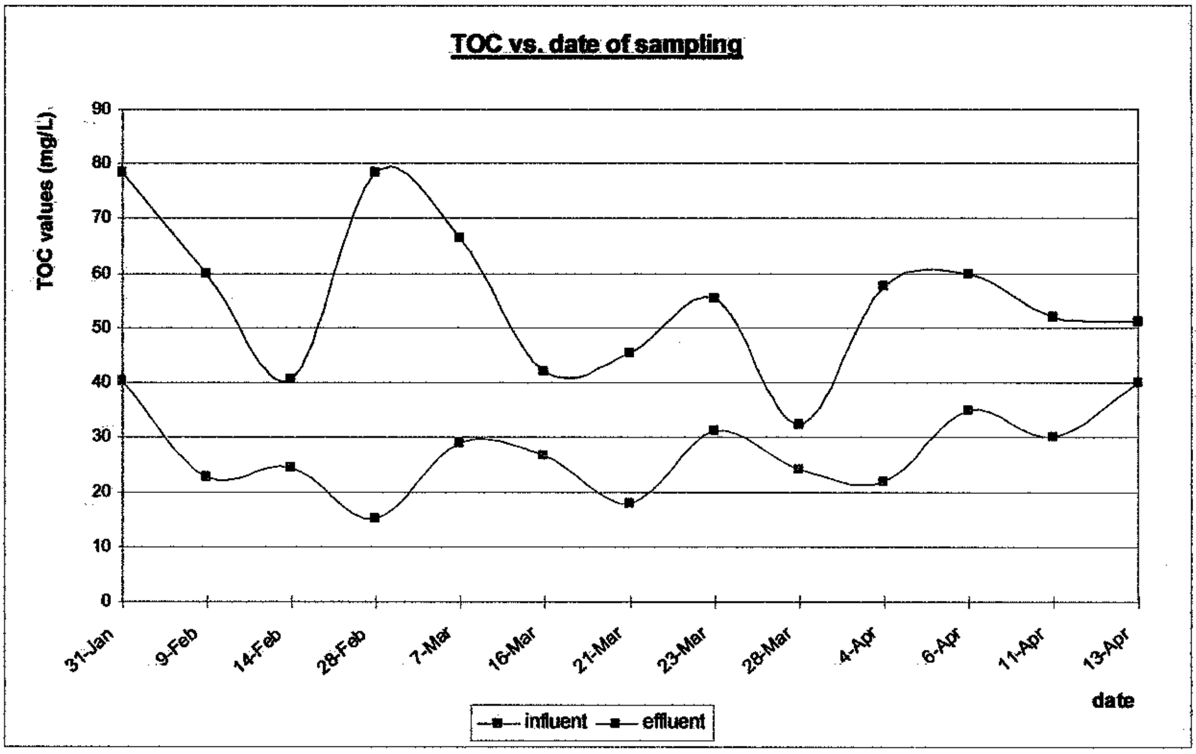

Figure 19. TOC vs. date of sampling (31/1/07-13/04/07)

Figure 19 shows the experiments performed for TOC by using 'grab sampling' method. The samples for this 'grab sampling' method were taken at the influent and effluent of the activated sludge treatment plant. The figure above also indicates that there is an inconsistency of TOC values from the influent to the effluent. The results on 31st January 2007 and 28th February 2007 differed among the other results, where the amounts of TOC value of the influent on both days were high (79 mg/L). TOC value for the influent proportion on 16th March 2007 dropped to 42 mg/L. This is because; it was during the university's mid-term semester break and only a few numbers of students were around. On 21st March to 23rd March, the amount of TOC values at the influent of STP rise up as the holidays ended and all students were back at the university. On 24th to 28th March 2007, the sewage treatment plant was under rectification works. On 28th March 2007 the sample was taken at oxidation pond, because the flow of wastewater shifted to the pond. Therefore, TOC values decreased and fluctuation will only start to increase after 28th March 2007. The effluent values of TOC appeared to be stable. This monitoring of UTP's STP proved that, after the rectification works, the result of every parameters were mostly under the discharge limits.

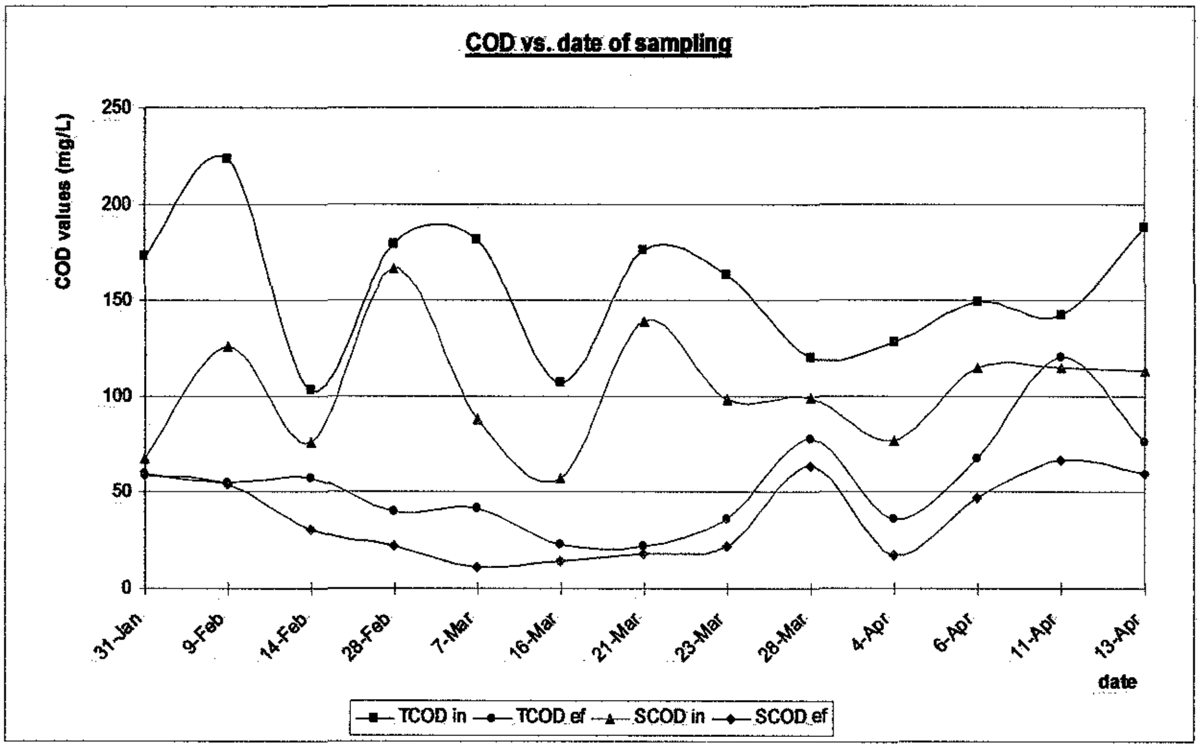

Figure 20. COD vs. date of sampling (31/1/07-13/4/07)

Referring to Figure 20, it shows that the amount of influent for TCOD value was highest on 9th February 2007 (223 mg/L), and dropped to 103.3 on 14th February 2007 (103.3 mg/L). This is because, the number of students were low due to the holiday season of Chinese New Year, where most of the Chinese students have gone back earlier. Values of TCOD at the sampling points, influent and effluent, were volatile in these experiments. The amount of TCOD rise back to 206.7 mg/L on 28th February 2007 and started to be lessen from 28th February to 16th March 2007. This situation occurred due to mid term semester break, as mention earlier, but the amount of TCOD values were stable after the holidays ended. This proved the result on the 21st and 23rd of March. The effluent values for TCOD in the other hand were in attenuation proportion and only started to increase after the rectification worked (24th – 28th March 2007) until 16th April 2007, and 11th April 2007 was the highest value of TCOD at effluent which was about 120mg/L. This condition due to the cleaning purposes at the clarifier.

For the SCOD, figure 20, exemplify the diminution of SCOD values for the influent and effluent sampling points from TCOD values. The samples need to be filtered for both sampling points (influent and effluent). The SCOD values and the pattern of the graph were much similar to the TCOD values, where it showed a proportional between the total and soluble of COD. It can be concluded here, that the result after the rectification worked still inconstant due the flow was not stabilized yet in the system. Therefore, the monitoring of the sewage treatment plant must be incessant to evaluate the progress.

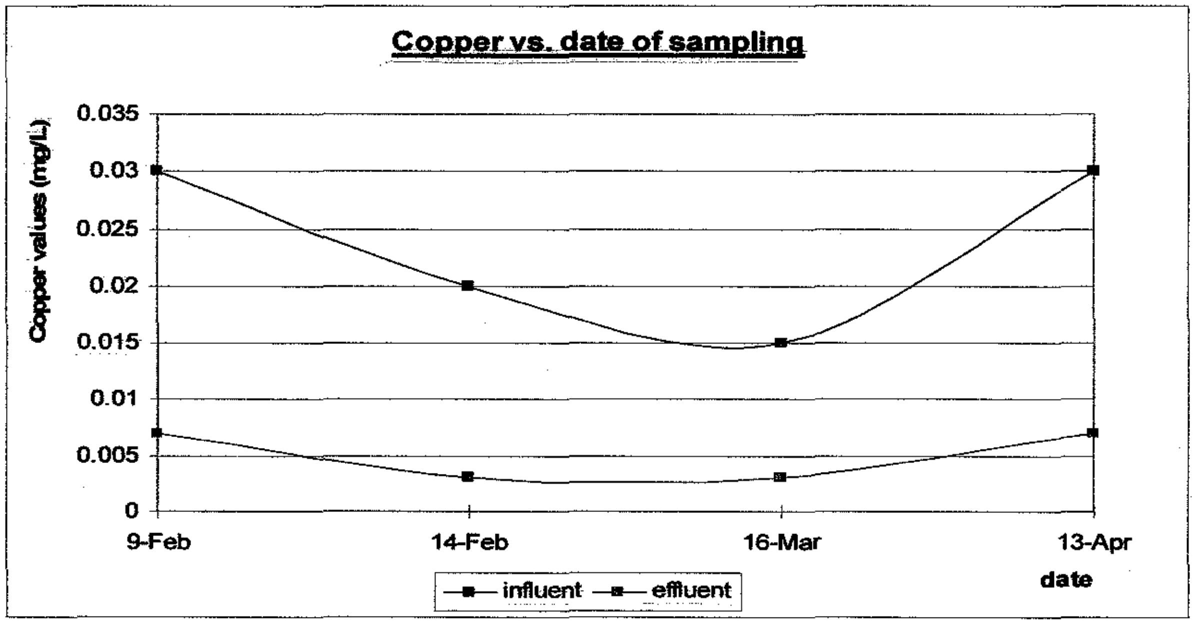

Figure 21. Copper vs. date of sampling (9/2/07-16/3/07)

Figure 21 shows the values of copper at the sampling point of influent and effluent of UTP's sewage treatment plant. The results indicate a small amount of copper. In the first phase of the study, results showed that less amount of copper occurred. As seen to the above figure, the amount of copper became much more less between 9th

February 2007- 16th March 2007 in both sampling points whether it was the influent or effluent. The copper amount at the effluent on 14th February and 16th March were unchanged at 0.003 mg/L. While for the influent, the values fell about ±0.005-0.01 mg/L from 9th February to 16th March 2007. On 13th April the copper values rise up at both sampling points, but still under the limits (see table 2.6, Metals of importance in wastewater management). This implies an acceptable value and would not be hazardous to aquatic life. This observation will be monitored continuously for an effective in optimizing the sewage treatment plant.

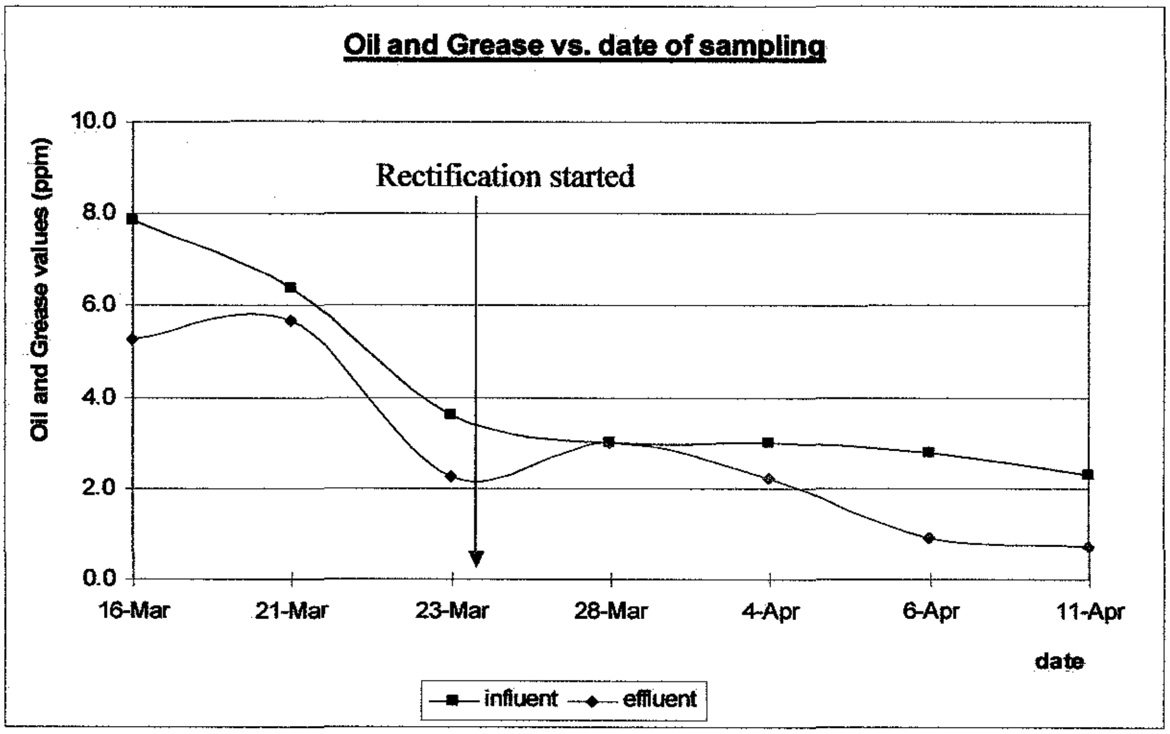

Figure 22. Oil and Grease vs. date of sampling (16/3/07-11/4/07)

Figure 22 shows the content of oil and grease in in the UTP's sewage treatment plant. It is seen that the amount of oil and grease was higher on16th March 2007, as it was at the end of the mid term break for the students and kept dropping off in stages or gradually until 28th March 2007. The reasons of this decreased situation, was probably due to the experiment that was just starting to be conducted and had difficulty on handling the apparatus which was not familiarized. Figure 22 also stated that the sewage treatment plant were under rectification works on 24th March 2007. The STP's operation was shut down on that date and will be operating again on 29th March 2007. Therefore, the samples on 28th March 2007 were not taken at the influent and effluent of the activated sludge system but at the influent and effluent of the stabilization pond. The graph above shows that there is a slight drop of 0.5 – 0.6 ppm at both sampling points. After the wastewater flow diverted back to the activated sludge treatment system, the results for oil and grease decreased until 11th April 2007.

By referring to table 2.5, Parameter limits of effluent by Environmental Quality Act 1974 it states that the discharge limit of oil and grease should be around 10 mg/L in wastewater sewage treatment plant, however figure 22 presented the amount of oils and greases discharge were decreased in every experiments until it dropped to 0.7 p.p.m on 11th April 2006. The values were too low and from this result and condition, it can be said that the system of oil and grease does not effectively work effectively.

As mentioned earlier, the grit chamber is equipped with a scum skimmer to remove oil and grease. However, grease clumps which have been observed after the rectification does not function as expected (refer to Figure 23, 24 and 25). This is probably due to the lack of maintenance and proper handling of the oil and grease traps which were provided to each café (refer Figure 26). The entire grease traps were not being cleaned at all by the cafe owners. Supposedly, these grease traps should and need to be cleaned regularly to avoid grease clumps.

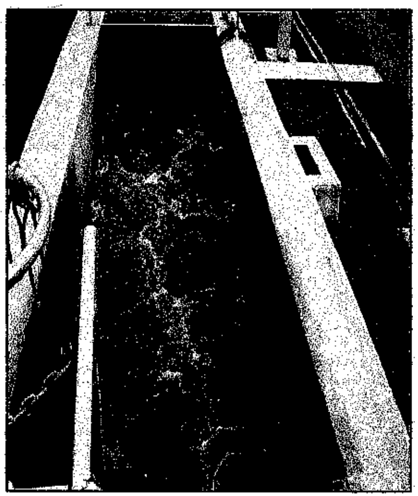

Figure 23. Oil and Grease Chamber (before rectification)

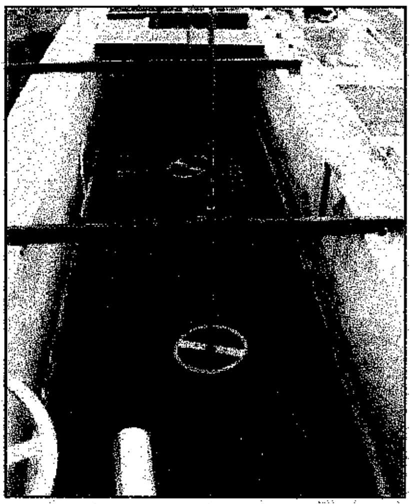

Figure 24. Oil and Grease Chamber (during rectification)

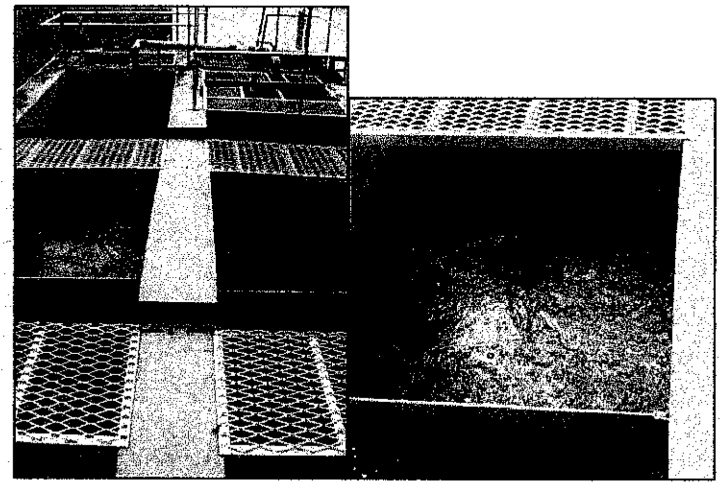

Figure 25. Oil and Grease Chamber (after rectified)

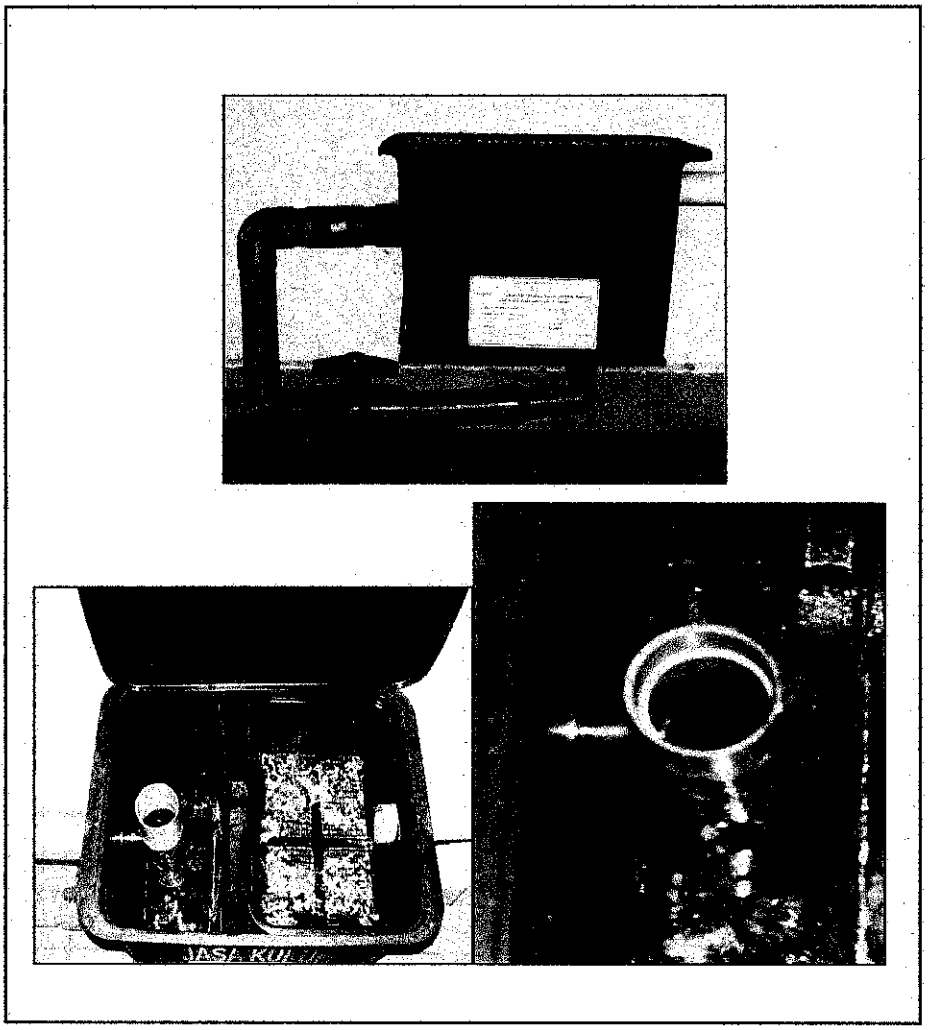

Figure 26. Oil and grease filter at café

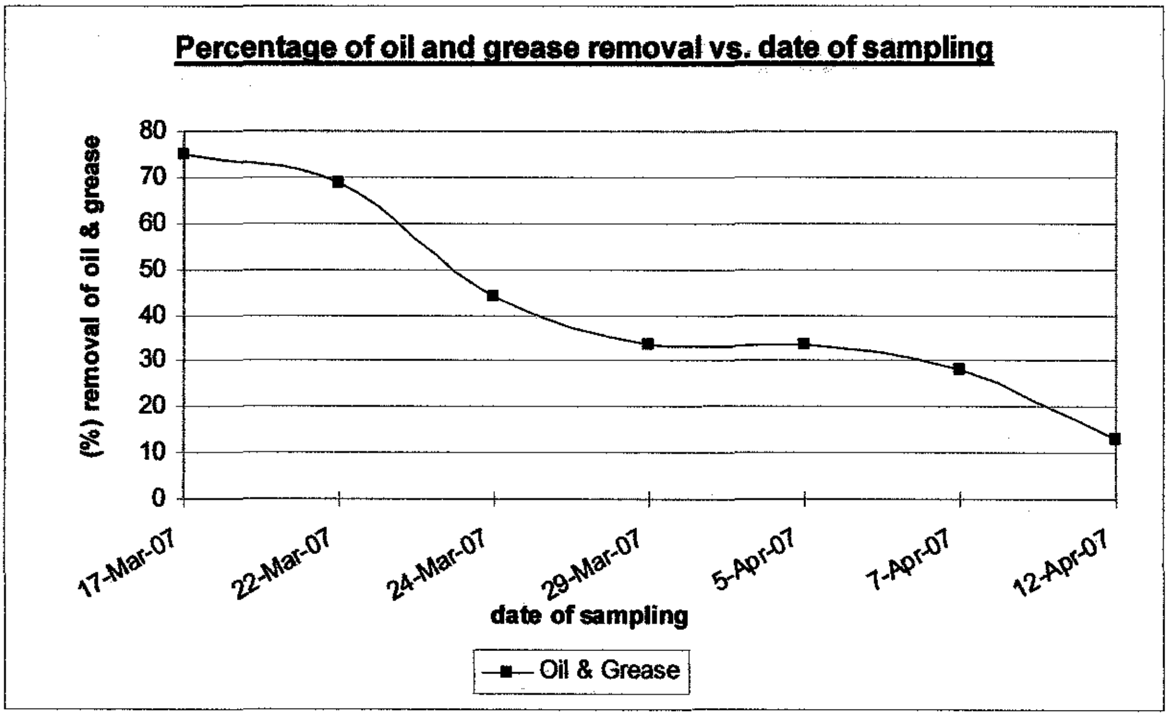

Figure 27. Percentage of Oil and Grease Removal vs. date of sampling

Figure 27, illustrated the percentage of oil and grease removal from 17th March – 12th April 2007, which shows the percentage removal decreased from day to day as the result of oil and grease discharge shown in figure 26. Therefore, an action must be taken for the system to remove the oil and grease at higher levels.

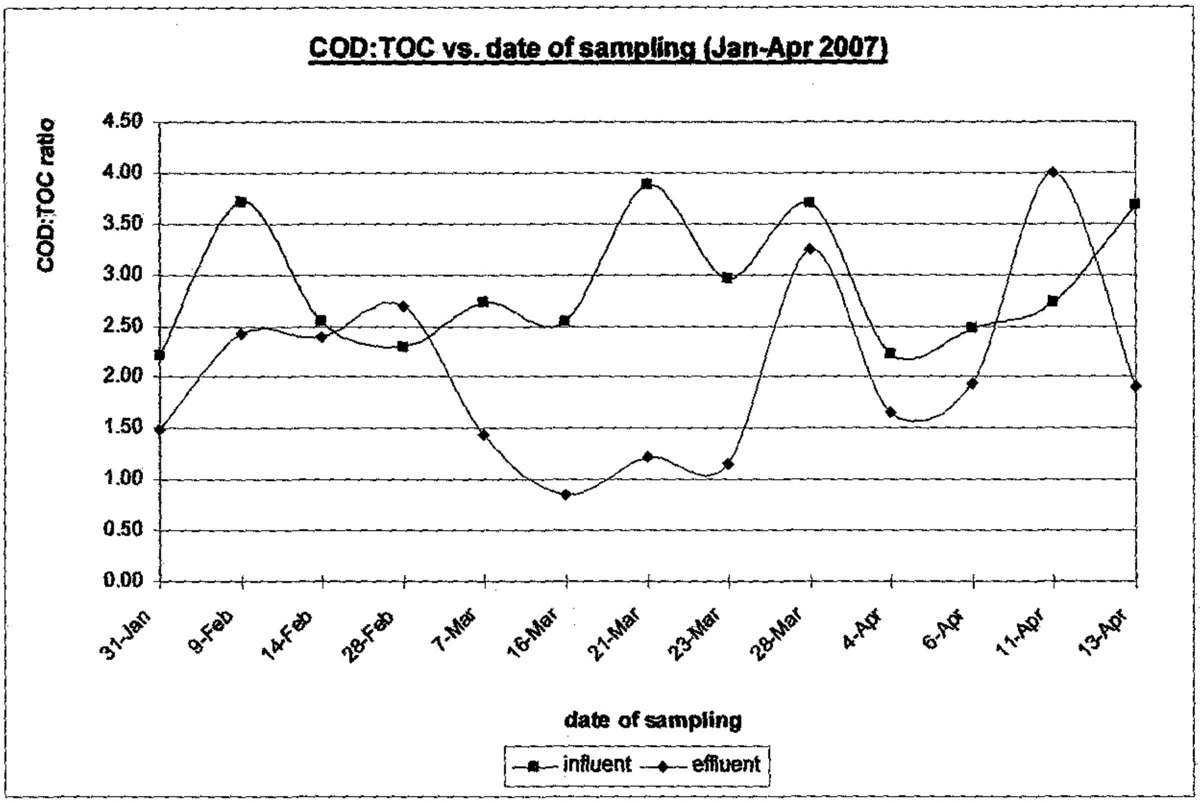

Figure 28. COD:TOC vs. times of day (31/1/07-13/4/07)

Figure 28; refer to the ratio of COD:TOC values. The results from the COD:TOC ratio formed the graph above. A high COD to TOC ratio in the influent indicates the presence of wastes that exert a chemical oxygen demand other than pure hydrocarbons that are biodegraded. Droste (1997) reported standard COD: TOC ratio of 4.16 and 2.3 for raw waste and treated effluent for municipal wastewater. Values obtained from the UTP's wastewater treatment plant were compared. Higher ratios in the effluent were observed in the wastewater treatment plant and not met the requirement. The results averagely were unstable and increased tremendously on 28th March 2007 and 11th April 2007, due to the rectification worked in progress and cleaning purposes at the clarifier. However, the above graph shows the average ratio of COD:TOC of UTP's sewage treatment plant for the influent (raw wastewater) was under the standard limits in the municipal wastewater, and results proved it but for the final effluent, it has still not met the requirement.

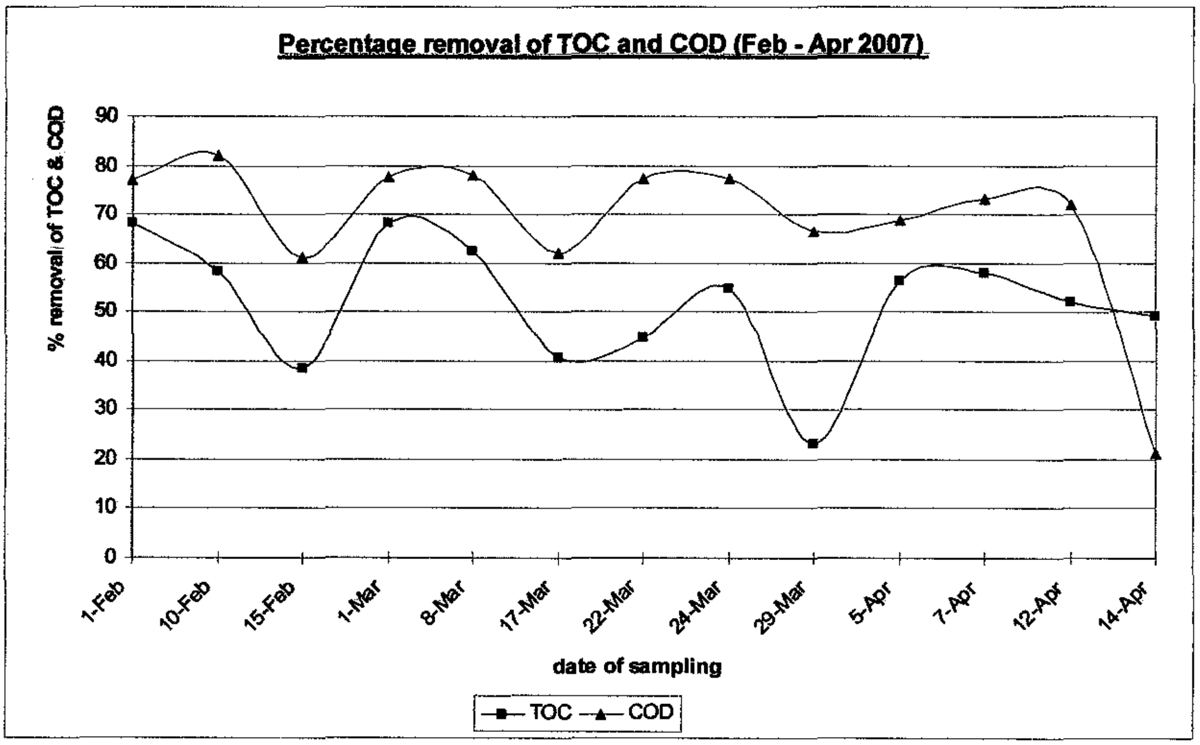

Figure 29. Percentage of Oil and Grease Removal vs. date of sampling

The percentage removal of COD is quit high around the range of 60 % to 80 % but only dropped drastically on 14th of April 2007 to 20 % as seen in figure 29. While for TOC percentage removal, the values were proportional with COD. Only on the 15th Feb 2007 and 29th March 2007, the percentage removals were less compare to the other days. The problems or defects that lead to this condition need to be solved to achieve 100% of TOC and COD removal.

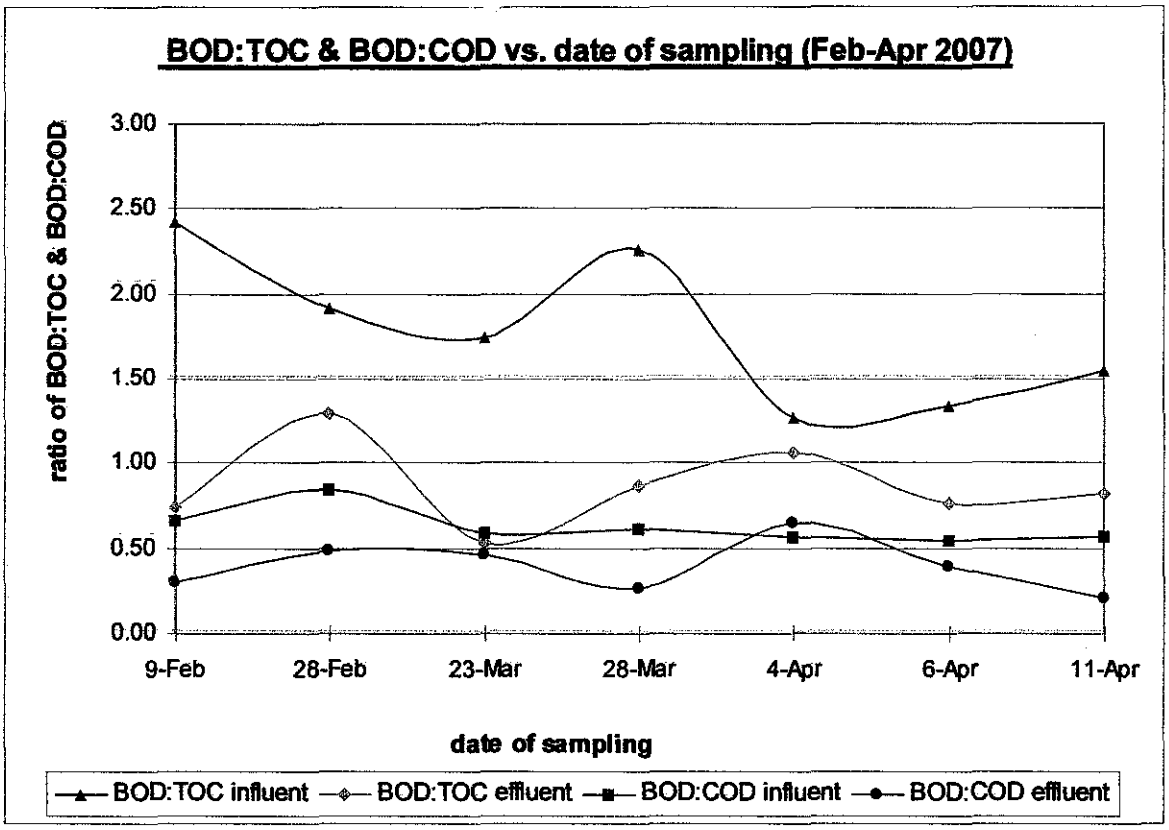

Figure 30. Ratio of BOD:TOC & BOD:COD vs. date of sampling (9/2/07 – 11/4/07)

Figure 30, showed the ratio of BOD:TOC and BOD:COD in UTP's sewage treatment plant. Comparing this figure above with Table 2.2 in the literature review chapter on comparison of ratios of various parameters used to characterize wastewater, the average ratio for influent (raw wastewater) of BOD:TOC should be at 1.6 mg/L while for BOD:COD it should be at 0.55 mg/L. If the BOD:COD ratio for untreated wastewater was 0.5 mg/L or greater, the waste can considered to be easily treatable by biological means and if the ratio is 0.3 mg/L or below, the waste may have some toxic components or acclimated microorganisms may be required in its stabilization. Therefore, it can be assumed that the waste in the UTP's sewage treatment plant was easy to be treated. As seen in the graph above, the ratio of effluent BOD:COD was in range of 0.3 to 0.6. Higher COD values at influent and effluent were responsible for higher BOD to COD ratio and also indicated the fraction of waste that cannot be consumed by the microorganisms. Higher ratios also indicate that the system is not efficiently removing the wastes. The plant is not performing at a desirable level of efficiency. TOC is also an indicator of the waste removal in the system. The ratio of BOD: TOC represents the ratio of oxygen required for biodegradation to the amount of organic carbon present in the system. The ratio of BOD: TOC in the effluent was in the range of 0.6 to 1.1 and respectively compared to 0.2 – 0.5 range in municipal treatment plant. The higher ratios of BOD: TOC also due to the high amount of TOC values.

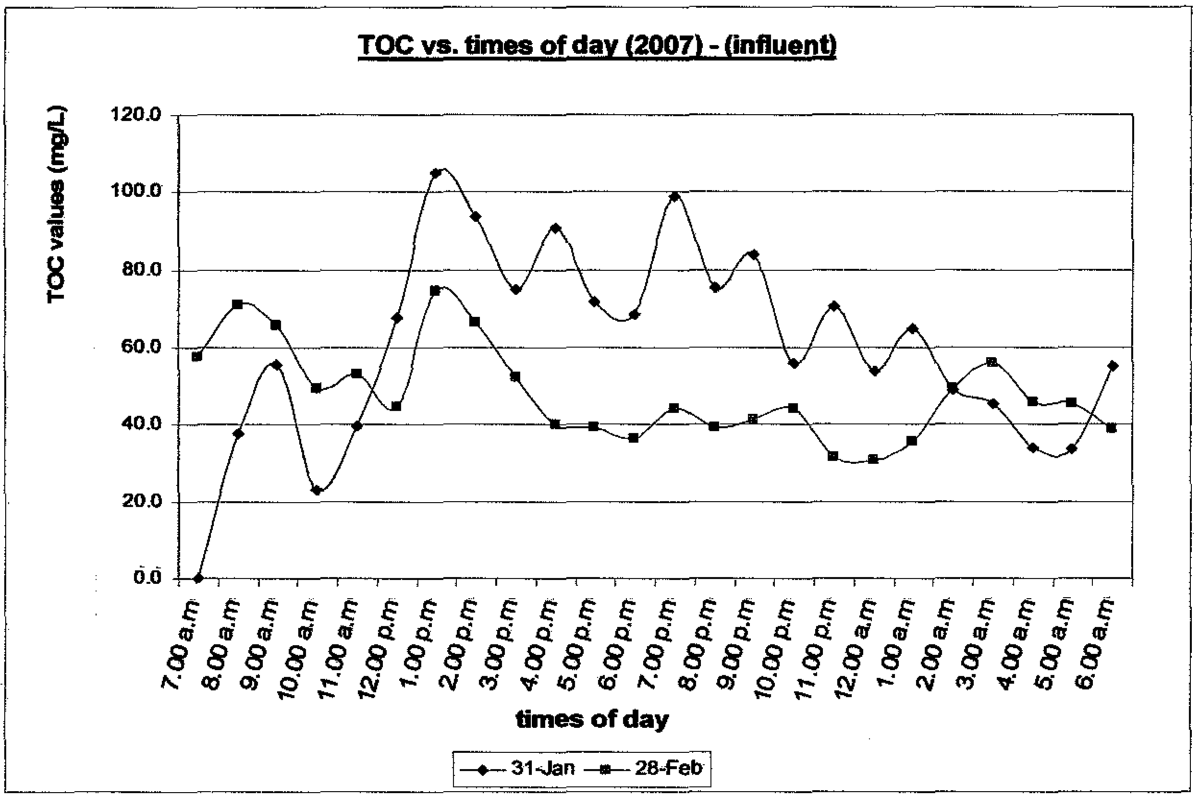

Figure 31. TOC vs. times of day (influent)

The samples for the '24 hours monitoring' method were taken at the influent of the activated sludge system. Figure 31 showed that the samples were taken on Tuesday 7.00a.m to Wednesday 6.00a.m (31st January 2007 and 28th February 2007). The result of this experiment showed that on 31st Jan 2007, the values of TOC were high around 12.00p.m to 1.00p.m and 6.00p.m to 7.00p.m, (refer figure 31). The values of TOC were also high on 31st Jan and 28th Feb 2007, at 8.00 am to 9.00 am, because it was during the meal hours (breakfast, lunch and dinner), where students, lecturers and also management staffs will contribute waste to the sewage treatment plant after they have taken their meals. The pattern of TOC amounts for both days were similar but the still inconstant. Since tst = 1.9 < tcr = 2.01, therefore there is no significant difference between the TOC results on 31st Jan and 28th Feb 2007 at 5% level of significant.

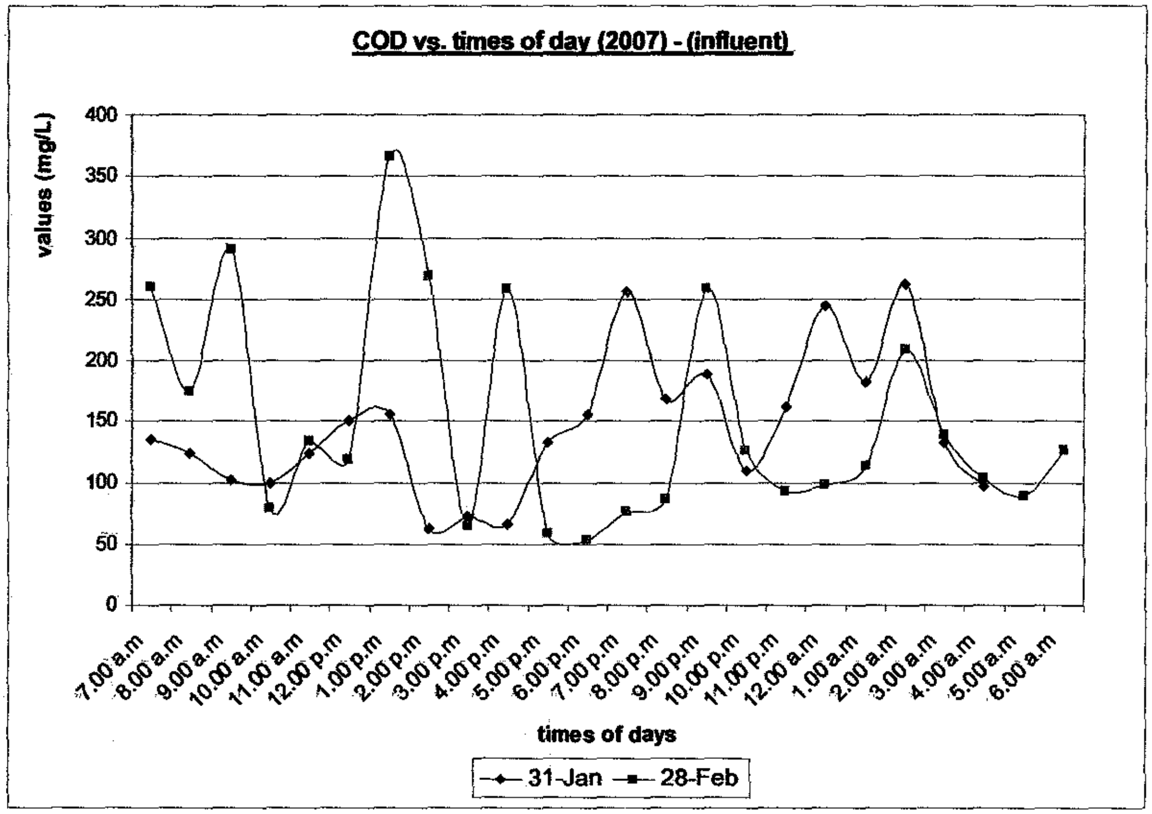

Figure 32. TSS, TOC, and COD vs. times of day (28/2/2007)

Figure 32 shows the results of another '24 hours monitoring' method. The sample was taken on Tuesday 7.00 a.m to Wednesday 6.00 a.m (31st January 2007 and 28th February 2007). The result of this experiment shows the values of COD varied in these two days. The values for COD were unstable. The amounts of COD were high on 28th February 2007 in the morning at 7.00a.m, in the afternoon at 1.00p.m to 4.00 p.m, at night on 9.00 p.m and also during late night at 2.00a.m. As mention earlier, the STP treated treats came from the hostels, new and old academic buildings, laboratories, cafes, chancellor hall, library and etc. The COD value was high around 7.00a.m; because the students probably just woke up and were prepared to go for their classes. It is also high during noon because of the lunch hour period and laboratory activities for most of the students conducted on that particular day. During the night, the COD values rise up to 258 mg/L on 9.00 p.m and at 2.00 a.m about 209 mg/L. The high values also decrease abruptly and not gradually on both days (31st January 2007 and 28th February 2007).

CHAPTER 5

CONCLUSION AND RECOMMENDATION

In the first phase of this study, the activated sludge treatment system was closed, and all the wastewaters flowed to the oxidation pond. Sampling for experiments were taken at the activated sludge system before it was closed for rectification works and at the influent of the oxidation pond. The sampling for the experiments were also taken during and before the fasting month, where the characteristic of TOC and copper in wastewater can be evaluated. From the experiments conducted, results showed that the values for TOC were fluctuated between the fasting month and the normal month. This was because, the activities during the fasting month such as cooking; for example started a bit late in the noon and early morning at around 1.00 am to 4.00 am, and not at regular times, where all the activities for cooking in normal month started in the morning, afternoon and also at night. While for copper, the results showed that this heavy metal (copper) would not be hazardous to aquatic life due to the amount which was too low in this municipal wastewater.

The second phase of this study was continuous from the first phase, but mainly focused on the activated sludge treatment system where it was fully operated in the mid of December 2006 after been rectified. In the second phase of this study, it covered the parameters of removal TOC, COD, Oil and Grease and heavy metal (copper). The percentage removal was calculated and showed that the percentage for COD and TOC were almost proportional and for oil and grease was lesser day by day. The range of COD removal was around 60% to 80% while for TOC was around 40% to 70%. Experiments were performed and results showed an improvement compared in the first phase of the study, which most results were complied with the government rules and regulation for COD and the others parameter (Oil and Grease and copper) were under the limits of general discharge limit Parameter Limits at Effluent of Standards A and B Environmental Quality Act 1974.

In order to achieve an effective system, all parts of the system must be function and regularly monitor. Hence to the experiments conducted, the system of oil and grease need to be improved. It is recommend to check the equipments used in the experiment and also the system of oil and grease at the activated sludge system, whether well functioned or not. If not, an action needs to be taken as to determine the efficiency removal of oil and grease.

REFERENCES

1) Metcalf & Eddy Inc (1992), *Wastewater Engineering Treatment and Reuse,* New York, Mc. Graw Hill.
2) Romalho R. S (1983*), Introduction to Wastewater Treatment Process*, 2nd Edition, United Kingdom, Academic Press.
3) Davies P. S B.Sc, Ph.D (2005), *The Biological Basis of Wastewater Treatment,* Strathkelvin Instruments Ltd.
4) Droste R. L (1997), *Theory and Practice of Water and Wastewater Treatment,* Canada, John Wiley & Sons. Inc
5) Hammer J. M. (1986), *Water and Wastewater Technology*, 5th Edition, New Jersey, Pearson Prentice Hall.
6) Tchonaglous G., Crites R.W (1998), *Small Decentralized Wastewater Management,* New York, Mc. Graw Hill.
7) Krist Gernaey, Herwig Bogaert, Peter Vonrolleghem (1998*), Sensors to Monitor Biogical Removal and Activated Sludge Settling.*
8) Pedro Sergio Fadini, Wilson F. Jardim, Jose Roberto Guimardes (2004), *Evaluation of Organic Load Measurement Techniques in a Sewage and Waste Stabilization.*
9) Al Enezi, Hamoda MF, Fawzi N, (2004), *Heavy Metals Content of Municipal Wastewater & Sludges in Kuwait.*
10) James E.Hairston, Leigh Stribling (1995), *Municipal Wastewater Treatment, Land Application of Municipal Wastewater.*
11) Hanna, *Chemical Oxygen Demand,* Hanna Laboratory Instruments.
12) P.Gurlois, G.Alric, J.P.Poroclion, G.Bridoux, J.Manem (1993), *The Elimination of Fats by Anaerobic Biological Treatment,* Tech. Sci. Mech.
13) N.G.Wakelin & C.F.Forster (1996), *An investigation into Microbial Removal of Fats, Oils & Greases.*

14) Shamsul Rahman Mohamed Kutty (2005), *Evaluation of Universiti Teknologi PETRONAS*, Sewage Treatment Plant

15) Parameter Limits Of Effluent Of Standards A and B, *Environmental Quality Act 1974* (ENVIRONMENTAL QUALITY (SEWAGE AND INDUSTRIAL EFFLUENTS) REGULATIONS 1978 [Regulation 8 (1), 8 (2), 8 (3)]

APPENDICES

1st PHASE OF STUDY

Data:-

Total Organic Carbon Result

Date: 10/8/2006
Thursday
Time: 4.30 pm

Grit Chamber			Aeration			Clarifier			Effluent		
Blank	Sample	Avg	Blank	Sample	Avg	Blank	Sample	Avg	Blank	Sample	Avg
0	67		0	104		0	27		0	17	
	76	72		38	24		75	30		17	19
	52			9			32			24	

Date: 11/8/2006
Friday
Time: 12.30 pm

Grit Chamber			Aeration			Clarifier			Effluent		
Blank	Sample	Avg	Blank	Sample	Avg	Blank	Sample	Avg	Blank	Sample	Avg
0	55		0	19		0	17		0	35	
	98	97		25	20		15	16		23	30
	96			15			33			33	

Date: 12/8/2006
Saturday
Time: 11.00 am

Grit Chamber			Aeration			Clarifier			Effluent		
Blank	Sample	Avg	Blank	Sample	Avg	Blank	Sample	Avg	Blank	Sample	Avg
0	65		0	35		0	41		0	31	
	19	66		46	41		28	27		29	30
	66			3			26			775	

Date: 15/8/2006
Tuesday
Time: 11.30 am

Grit Chamber			Aeration			Clarifier			Effluent		
Blank	Sample	Avg	Blank	Sample	Avg	Blank	Sample	Avg	Blank	Sample	Avg
0	30		0	64		0	28		0	4	
	49	40		50	55		153	26		12	7
	69			52			23			6	

TSS Results

	SAMPLE POINT		DATE @TIME			
			10/8 @4.30 p.m.	11/8 @12.30 p.m.	12/8 @11.00 a.m.	15/8 @11.30 a.m.
Average TSS value (mg/L)	1	Influent	38.00	54.00	41.33	17.33
	2	After Grit Chamber	81.00	15.67	32.33	120.67
	3	Aeration Tank	67.00	11.00	29.33	277.67
	4	Clarifier	26.00	22.00	17.00	156.67
	6	Effluent	34.67	13.67	22.00	21.33

Sample taken from the oxidation pond
(at the influent) 19th September 2006
TOC Results

Time	Sample No. 1	Result mg/L	Average
6.00 p.m	1	37 26	31.5
6.30 p.m	2	45 49	47
7.00 p.m	3	36 54	45
7.30 p.m	4	61 51	56
8.00 p.m	5	32 27	29.5
8.30 p.m	6	34 39	36.5
9.00 p.m	7	26 28	27
9.30 p.m	8	73 72	72.5
10.00 p.m	9	43 32	37.5
10.30 p.m	10	18 24	21
11.00 p.m	11	42 33	37.5
11.30 p.m	12	64 114	89
12.00 p.m	13	75 241	158
12.30 a.m	14	62 63	62.5
1.00 a.m	15	56 52	54
1.30 a.m	16	60 61	60.5
2.00 a.m	17	71 68	69.5
2.30 a.m	18	70 50	60
3.00 a.m	19	80 72	76
3.30 a.m	20	47 49	48

4.00 a.m	21	52	54.5
		57	
4.30 a.m	22	45	48.5
		52	
5.00 a.m	23	42	39.5
		37	
5.30 a.m	24	39	35.5
		32	

Sample taken from the oxidation pond (at the influent) 19th September 2006

TOC, COD, TSS Results

TOC		COD		TSS	
6.00 p.m	31.5	6.00 p.m	24	6.00 p.m	10
6.30 p.m	47	6.30 p.m	40	6.30 p.m	19
7.00 p.m	45	7.00 p.m	92	7.00 p.m	8
7.30 p.m	56	7.30 p.m	31	7.30 p.m	18
8.00 p.m	29.5	8.00 p.m	52	8.00 p.m	17
8.30 p.m	36.5	8.30 p.m	13	8.30 p.m	13
9.00 p.m	27	9.00 p.m	25.5	9.00 p.m	7
9.30 p.m	72.5	9.30 p.m	25.5	9.30 p.m	3
10.00 p.m	37.5	10.00 p.m	47	10.00 p.m	30
10.30 p.m	21	10.30 p.m	11.5	10.30 p.m	65
11.00 p.m	37.5	11.00 p.m	8.5	11.00 p.m	105
11.30 p.m	89	11.30 p.m	127	11.30 p.m	34
12.00 p.m	158	12.00 p.m	23.5	12.00 p.m	4
12.30 a.m	62.5	12.30 a.m	21.5	12.30 a.m	11
1.00 a.m	54	1.00 a.m	8	1.00 a.m	9
1.30 a.m	60.5	1.30 a.m	26	1.30 a.m	4
2.00 a.m	69.5	2.00 a.m	13.5	2.00 a.m	4
2.30 a.m	60	2.30 a.m	49	2.30 a.m	11
3.00 a.m	76	3.00 a.m	45	3.00 a.m	6
3.30 a.m	48	3.30 a.m	15.5	3.30 a.m	7
4.00 a.m	54.5	4.00 a.m	19	4.00 a.m	11
4.30 a.m	48.5	4.30 a.m	13.5	4.30 a.m	8
5.00 a.m	39.5	5.00 a.m	27	5.00 a.m	10
5.30 a.m	35.5	5.30 a.m	20	5.30 a.m	16

Sample taken from the oxidation pond
(at the influent)
TOC Results

Time	Smp	6-Oct		9-Oct		14-Oct		17-Oct	
		Result mg/L	Avg	Result mg/L	Avg	Result mg/L	Avg	Result mg/L	Avg
7.00 a.m	1	33	34.0	33	44.0	13	14.5	34	40.0
		35		55		16		46	
8.00 a.m	2	41	32.0	23	102.0	19	17.0	43	46.0
		23		181		15		49	
9.00 a.m	3	175	100.5	36	34.0	0	1.0	38	41.0
		26		32		2		44	
10.00 a.m	4	9	12.5	14	22.0	9	6.5	38	43.0
		16		30		4		48	
11.00 a.m	5	40	34.0	35	28.5		0.0	31	26.5
		28		22				22	
12.00 p.m	6	29	175.5	31	35.0	8	9.0	25	25.5
		322		39		10		26	
1.00 p.m	7	28	32.5	21	23.5	15	15.5	35	24.5
		37		26		16		14	
2.00 p.m	8	20	17.0	38	36.5	23	22.0	27	25.0
		14		35		21		23	
3.00 p.m	9	28	31.5	24	26.0	11	9.5	27	26.5
		35		28		8		26	
4.00 p.m	10	21	26.5	36	53.5	3	4.0	19	17.0
		32		71		5		15	
5.00 p.m	11	18	17.0	39	28.5	31	29.0	17	19.5
		16		18		27		22	
6.00 p.m	12	23	17.5	13	22.0	16	11.0	23	19.5
		12		31		6		16	
7.00 p.m	13	39	37.5	30	25.5	127	85.5	31	38.5
		36		21		44		46	
8.00 p.m	14	57	54.0	34	32.0	12	16.5	37	39.0
		51		30		21		41	
9.00 p.m	15	27	31.0	30	30.0	22	22.5	22	21.5
		35		30		23		21	
10.00 p.m	16	63	67.5	60	52.0	10	12.0	23	24.5
		72		44		14		26	
11.00 p.m	17	20	28.0	42	58.5	4	6.0	5	20.5
		36		75		8		36	
12.00 a.m	18	21	22.5	41	39.5	15	12.5	31	28.5
		24		38		10		26	
1.00 a.m	19	36	49.0	24	31.0	30	18.0	31	30.5
		62		38		6		30	

Time	Smp	6-Oct		9-Oct		14-Oct		17-Oct	
		Result	Avg	Result	Avg	Result	Avg	Result	Avg
		mg/L		mg/L		mg/L		mg/L	
2.00 a.m	20	63	61.5	32	34.5	22	23.0	44	37.0
		60		37		24		30	
3.00 a.m	21	65	65.5	38	46.0	51	45.5	23	24.0
		66		54		40		25	
4.00 a.m	22	59	53.5	24	23.5	32	28.5	32	24.0
		48		23		25		16	
5.00 a.m	23	40	38.0	10	21.5	15	10.5	36	38.5
		36		33		6		41	
6.00 a.m	24	53	54.5	136	82.0	23	19.5	25	21.0
		56		28		16		17	

COD:TOC RATIO VALUES (6/10/06 – 17/10/06)

	6-Oct COD:TOC (mg/L)	**9-Oct COD:TOC (mg/L)**	**14-Oct COD:TOC (mg/L)**	**17-Oct COD:TOC (mg/L)**
7.00 a.m	3.25	3.52	10.86	4.13
8.00 a.m	9.26	1.12	3.79	1.96
9.00 a.m	1.11	4.25	6.94	3.61
10.00 a.m	1.28	3.91	16.92	2.43
11.00 a.m	3.73	3.35	3.32	3.12
12.00 p.m	1.56	3.76	27.61	4.21
1.00 p.m	2.69	3.15	6.97	3.52
2.00 p.m	5.76	3.12	5.50	4.97
3.00 p.m	3.44	5.71	8.37	5.82
4.00 p.m	2.44	3.21	28.38	11.41
5.00 p.m	1.12	2.56	4.90	3.62
6.00 p.m	5.09	3.47	5.55	4.36
7.00 p.m	4.53	3.57	1.51	2.35
8.00 p.m	3.19	4.23	5.70	2.87
9.00 p.m	2.60	3.05	7.38	3.21
10.00 p.m	2.09	4.26	6.13	6.94
11.00 p.m	5.05	3.97	16.67	11.14
12.00 a.m	3.60	2.18	5.60	2.68
1.00 a.m	1.96	2.29	4.44	2.31
2.00 a.m	0.86	2.04	2.61	1.82
3.00 a.m	0.99	3.26	3.95	6.81
4.00 a.m	0.95	1.99	4.77	2.43
5.00 a.m	1.71	1.91	11.33	1.63
6.00 a.m	2.50	2.49	4.87	9.10

2nd PHASE OF STUDY

TOC
Samples taken at UTP's STP

Date	Influent	Avg. Influent	Effluent	Avg. Effluent
31-Jan-07	90	78.5	33	40.3
	36		44	
	67		44	
9-Feb-07	57	60.0	25	25.3
	63		30	
	60		21	
14-Feb-07	42	40.5	22	24.3
	82		20	
	39		31	
28-Feb-07	81	78.7	18	15.3
	76		12	
	79		16	
7-Mar-07	67	66.3	23	29.0
	66		35	
	66		29	
16-Mar-07	39	42.0	27	26.7
	41		28	
	46		25	
21-Mar-07	50	45.3	16	18.0
	39		17	
	47		21	
23-Mar-07	56	55.3	34	31.3
	53		32	
	57		28	
28-Mar-07	33	32.5	36	24.0
	51		16	
	32		20	
4-Apr-07	40	57.5	23	22.0
	53		25	
	62		18	
6-Apr-07	65	59.5	37	35.3
	78		35	
	54		34	
11-Apr-07	48	52.0	21	29.5
	101		106	
	56		38	
13-Apr-07	54	51.0	39	40.0
	48		44	
	88		37	

TCOD
Samples taken at
UTP's STP

Date	Influent	Avg. Influent	Effluent	Avg. Effluent
31-Jan-07	175	173.3	64	59.7
	167		56	
	178		59	
9-Feb-07	224	223.0	57	55.0
	232		62	
	213		46	
14-Feb-07	93	103.3	65	57.5
	112		21	
	105		50	
28-Feb-07	170	179.5	40	40.3
	243		41	
	189		40	
7-Mar-07	173	181.3	18	41.5
	153		36	
	218		47	
16-Mar-07	115	106.7	26	23.0
	105		20	
	100		9	
21-Mar-07	181	176.0	51	22.0
	173		24	
	174		20	
23-Mar-07	181	176.0	40	36.0
	173		32	
	174		36	
28-Mar-07	119	120.3	81	78.0
	123		77	
	119		76	
4-Apr-07	136	128.3	32	36.3
	126		39	
	123		38	
6-Apr-07	148	149.0	72	67.5
	155		51	
	144		63	
11-Apr-07	141	142.0	118	120.0
	139		119	
	146		123	
13-Apr-07	180	188.0	77	76.0
	195		82	
	189		75	

SCOD
Samples taken at
UTP's STP

Date	Influent	Avg. Influent	Effluent	Avg. Effluent
31-Jan-07	67 68 126	67.5	56 64 57	59.0
9-Feb-07	114 120 143	125.7	58 48 55	53.7
14-Feb-07	70 86 73	76.3	36 34 22	30.7
28-Feb-07	178 156 166	166.7	22 22 24	22.7
7-Mar-07	86 91 86	87.7	11 10 12	11.0
16-Mar-07	60 56 56	57.3	15 12 15	14.0
21-Mar-07	134 166 145	139.5	19 19 17	18.3
23-Mar-07	90 104 101	98.3	30 17 18	17.5
28-Mar-07	107 96 95	99.3	69 59 63	63.7
4-Apr-07	76 74 82	77.3	17 19 15	17.0
6-Apr-07	113 112 121	115.3	45 49 47	47.0
11-Apr-07	111 116 117	114.7	64 65 73	67.3
13-Apr-07	114 114 111	113.0	60 72 59	59.5

Oil and Grease values taken at
UTP's STP

Date	Influent	Avg. Influent	Effluent	Avg. Effluent
16-Mar-07	12.5		5.05	
	8	7.9	8	5.3
	7.75		5.45	
21-Mar-07	7.15		6	
	6.45	6.4	4.5	5.7
	5.6		6.5	
23-Mar-07	3.75		1.5	
	7.5	3.6	3	2.3
	3.5		7.25	
28-Mar-07	4		3	
	2.5	3.0	4	3.0
	2.5		2	
4-Apr-07	3		2	
	3.5	3.0	3	2.2
	2.5		1.5	
6-Apr-07	2.5		1	
	3.5	2.8	1	0.9
	2.5		0.75	
11-Apr-07	2		1	
	2.5	2.3	0.5	0.7
	2.5		0.5	

COPPER

Samples taken at
UTP's STP

Date	Influent	Avg. Influent	Effluent	Avg. Effluent
9-Feb-07	-0.02	0.03	0.04	0.007
	0.05		-0.01	
	0.06		-0.01	
14-Feb-07	0.03	0.013	-0.01	0.003
	0.01		-0.01	
	0		0.03	
16-Mar-07	0.04	0.015	0.02	0.003
	0.015		-0.01	
	-0.01		0	
13-Apr-07	0.01	0.03	-0.06	0.007
	0.05		0.07	
	0.03		0.01	

Data: Percentage removal of oil and grease

Date	influent	effluent	% removal
17-Mar-07	7.9	5.9	75
22-Mar-07	6.4	4.4	69
24-Mar-07	3.6	1.6	44
29-Mar-07	3.0	1.0	33
5-Apr-07	3.0	1.0	33
7-Apr-07	2.8	0.8	28
12-Apr-07	2.3	0.3	13

Data: Percentage removal of COD

Date	TOC % removal	COD % removal
1-Feb	68	77
10-Feb	58	82
15-Feb	38	61
1-Mar	68	78
8-Mar	62	78
17-Mar	40	62
22-Mar	45	77
24-Mar	55	77
29-Mar	23	67
5-Apr	57	69
7-Apr	58	73
12-Apr	52	72
14-Apr	49	21

Result for BOD/COD & BOD:TOC ratio:-

	BOD:TOC		BOD:COD	
Date	Influent	Effluent	Influent	Effluent
9-Feb	2.43	0.74	0.65	0.30
28-Feb	1.91	1.29	0.84	0.48
23-Mar	1.75	0.54	0.59	0.47
28-Mar	2.26	0.87	0.61	0.27
4-Apr	1.27	1.06	0.57	0.64
6-Apr	1.34	0.76	0.54	0.39
11-Apr	1.54	0.82	0.57	0.21

Result for COD:TOC ratio:-

	COD:TOC	
Date	Influent	Effluent
31-Jan	2.21	1.48
9-Feb	3.72	2.42
14-Feb	2.55	2.39
28-Feb	2.29	2.69
7-Mar	2.73	1.43
16-Mar	2.54	0.86
21-Mar	3.89	1.22
23-Mar	2.96	1.15
28-Mar	3.70	3.25
4-Apr	2.23	1.65
6-Apr	2.48	1.94
11-Apr	2.73	4.00
13-Apr	3.69	1.90

Overall results data sheet:-

Sampling Day	Date	Influent									Effluent									
		TSS	**TCOD**	**SCOD**	**TOC**	**TBOD**	**SBOD**	**NH3**	**NO3**	**P**	**TSS**	**TCOD**	**SCOD**	**TOC**	**TBOD**	**SBOD**	**CBOD**	**NH3**	**NO3**	**P**
Wednesday	31-Jan-07	98	173	87	64	56	-	31.0	1.0	68.3	33	60	59	40	91	-	-	31.3	1.9	65.6
Friday	9-Feb-07	157	223	126	60	146	57	2.2	0.4	266.1	62	55	54	23	17	-8	6	1.4	4.5	225.7
Wednesday	14-Feb-07		103	76	54			0.8	0.3	184.5		45	31	24				0.0	2.5	183.4
Friday	23-Feb-07					135	85								28	17	22			
Wednesday	28-Feb-07	142	207	167	79	150	107				39	41	22	15	19	16	15			
Friday	2-Mar-07					160	112								11	9	10			
Wednesday	7-Mar-07	196	181	88	66			23.1	0.2	186.2	46	34	11	29				19.9	0.6	88.1
Friday	9-Mar-07							18.7	0.1	390.4								10.8	0.5	293.1
Wednesday	14-Mar-07					132	91	15.2	0.1	175.2					9	9	9	1.9	4.1	135.2
Friday	16-Mar-07	97	107	57	42						56	18	14	27						
Wednesday	21-Mar-07	130	176	148	45			24.0	0.0	276.3	50	32	18	18				1.9	8.2	181.6
Friday	23-Mar-07	105	164	98	55	97	48				61	36	22	31	17	13	4			
Wednesday	28-Mar-07	103	120	99	39	74	56	16.6	-0.2	196.9	54	78	64	24	21	18	15	9.1	-0.9	179.1
Wednesday	4-Apr-07		128	77	58	73	56					36	17	22	23	14	15			
Thursday	5-Apr-07					58	35								24	12	17			
Friday	6-Apr-07	87	149	115	60	80	55	22.6	0.5	173.7	41	68	47	35	25	15	19	27.4	0.7	153.0
Wednesday	11-Apr-07	95	142	115	52	80	42	49.4	0.4	173.8	82	120	67	30	25	9	11	41.3	0.3	134.9
Friday	13-Apr-07	58	188	113	51			15.8	0.1	173.6	76	76	60	40				16.6	1.1	148.8

Overall results calculations:-

Date	Q (m3/hr)	Q (m3/dy)	Influent TSS (mg/L)	Effluent TSS (mg/L)	MLSS (mg/L)	MLVSS (mg/L)	Sludge Wasted (m3/hr)	Influent BOD (mg/L)	(Conc of BOD x Q) kg of BOD.day	Influent COD (mg/L)	Influent kg of COD/day	Effluent COD (mg/L)	Effluent kg of COD/day
31-Jan-07	290	6960	98	33				55.5	386.28	173	1206.17	60	415.51
9-Feb-07	270	6480	94	62	1420			145.7	944.14	223	1445.04	55	356.40
14-Feb-07	320	7680								71.7	550.66	58	441.60
23-Feb-07	300	7200						135.3	974.52				
28-Feb-07	280	6720	142	39	1600			150.2	1009.34	206.5	1387.68	40	270.82
2-Mar-07	280	6720					140	160.0	1074.98				
7-Mar-07	290	6960	212	46	1130					181.3	1261.85	42	288.84
14-Mar-07	320	7680											
16-Mar-07	320	7680	97	56	1337	1175		131.8	1011.97	106.7	819.46	23	176.64
21-Mar-07	300	7200	130	50	1235					176	1267.20	22	158.40
22-Mar-07	271	6504					271						
23-Mar-07	332	7968	105	61	1715	1440		96.6	769.71	163.7	1304.36	36	286.85
28-Mar-07	300	7200	103	54				73.6	529.92	120.3	866.16	78	561.60
4-Apr-07	289	6936						73.2	507.83	128	889.89	36	251.78
5-Apr-07	285	6840						57.9	396.04				
6-Apr-07	287	6888	87	41	108	84		80.2	552.07	149	1026.31	68	468.38
11-Apr-07	265	6360	95	82	753	275		80.3	510.71	142	903.12	120	763.20
13-Apr-07	268	6432	58	76	755	328		0.00	0.00	188	1209.22	76	488.83

Data: Statistical Analysis for TOC 6/10/2006 – 17/10/2006

t-Test: Two-Sample Assuming Equal Variances

	6-Oct	9-Oct
Mean	45.54167	38.8125
Variance	1179.585	384.735
Observations	24	24
Pooled Variance	782.1601	
Hypothesized Mean Difference	0	
df	46	
t Stat	0.833497	
P(T<=t) one-tail	0.204436	
t Critical one-tail	1.67866	
P(T<=t) two-tail	0.408872	
t Critical two-tail	2.012896	

t-Test: Two-Sample Assuming Equal Variances

	6-Oct	*14-Oct*
Mean	45.54167	18.2917
Variance	1179.585	305.955
Observations	24	24
Pooled Variance	742.7699	
Hypothesized Mean Difference	0	
df	46	
t Stat	3.463618	
P(T<=t) one-tail	0.000582	
t Critical one-tail	1.67866	
P(T<=t) two-tail	0.001164	
t Critical two-tail	2.012896	

Data: Statistical Analysis for TOC 6/10/2006 – 17/10/2006

t-Test: Two-Sample Assuming Equal Variances

	6-Oct	18-Oct
Mean	45.54167	29.2292
Variance	1179.585	75.8256
Observations	24	24
Pooled Variance	627.7054	
Hypothesized Mean Difference	0	
df	46	
t Stat	2.25545	
P(T<=t) one-tail	0.014453	
t Critical one-tail	1.67866	
P(T<=t) two-tail	0.028906	
t Critical two-tail	2.012896	

t-Test: Two-Sample Assuming Equal Variances

	9-Oct	14-Oct
Mean	38.8125	18.29167
Variance	384.73505	305.9547
Observations	24	24
Pooled Variance	345.34488	
Hypothesized Mean Difference	0	
df	46	
t Stat	3.8252437	
P(T<=t) one-tail	0.0001959	
t Critical one-tail	1.6786604	
P(T<=t) two-tail	0.0003919	
t Critical two-tail	2.0128956	

Data: Statistical Analysis for TOC 6/10/2006 – 17/10/2006

t-Test: Two-Sample Assuming Equal Variances

	9-Oct	18-Oct
Mean	38.8125	29.22917
Variance	384.73505	75.82563
Observations	24	24
Pooled Variance	230.28034	
Hypothesized Mean Difference	0	
df	46	
t Stat	2.1876547	
P(T<=t) one-tail	0.0169069	
t Critical one-tail	1.6786604	
P(T<=t) two-tail	0.0338139	
t Critical two-tail	2.0128956	

Data: Statistical Analysis for TOC 31/1/2007 – 28/2/2007

t-Test: Two-Sample Assuming Equal Variances

	31-Jan	28-Feb
Mean	59.72222	48.0625
Variance	730.9436	144.3329
Observations	24	24
Pooled Variance	437.6383	
Hypothesized Mean Difference	0	
df	46	
t Stat	1.930728	
P(T<=t) one-tail	0.029847	
t Critical one-tail	1.67866	
P(T<=t) two-tail	0.059694	
t Critical two-tail	2.012896	