Impact of Chemical Waste Discharge on BOD Removal in Sewerage Treatment Plant

by

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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,

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(Dr Shamsul Rahman Bin Mohammed Kutty)

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TRONOH, PERAK
DECEMBER 2004

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 contain herein have not been undertaken or done by unspecified sources or persons.

MOHD FADLY BIN NOR AZMAN

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ABSTRACT

The performance system of the aeration tank and clarifier was studied to enhance the performance of University Technology Petronas (UTP) sewage treatment plant (STP). A pilot plant with feeder tank, aeration tank and clarifier was used to simulate UTP's STP.

The parameters evaluated in the study were biological oxygen demand (BOD), the concentration of dissolve oxygen (DO) and the performance of pilot plant after the addition of segregated chemical waste. To simulate the exact condition of existing UTP's STP, the flowrate was scaled down from 0.4 Ml/hour in the STP to only 4 l/hour in pilot plant, which is about 1:6 ratio.

For the first five weeks, no return activated sludge from clarifier to aeration tank to simulate the problem in the STP. For the last five weeks, the activated sludge pilot plant was operated in normal condition. Chemical waste (approximately 20% concentration from total influent) from chemical blocks was also added in stages into the feeder tank along with the normal wastewater.

The highest BOD influent value for STP and pilot plant were 92 mg/l and 30 mg/l, respectively. The highest BOD effluent value for STP and pilot plant were 22 mg/l and 11 mg/l, respectively. The addition of 20% segregated chemical waste from chemical blocks did not have any significant effects to the performance of pilot plant.

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CHAPTER 1

INTRODUCTION

1.1 Background

University Technology Petronas recently constructed a new STP to treat all waste streams from the surrounding residential area prior to discharge into the main drain. The STP is an activated sludge system designed for 23,000 population equivalent with design flowrate of 5,175 m^3/day. The design effluent limit for standard A is 50 mg/l TSS and 20 mg/l BOD. The STP consists of two aeration tanks, two clarifier tanks, primary screen chamber, secondary screen chamber, grit chamber, chlorination tank, gravity thicker and sludge holding tank. Presently, only the first aeration tank was used due to low hydraulic loading. UTP employed Loyal Wastewater Engineering Sdn. Bhd, to operate and maintaine the STP. Loyal Wastewater Engineering Sdn. Bhd employed Spectrum Laboratories (Penang) Sdn. Bhd to analyze the quality of effluent discharge from the sewage treatment plant. Two parameters were checked for the effluent discharge sample. The parameters analyzed were pH, BOD and concentration of DO.

1.2 Problem Statement

There are few problems in the STP. There is algae growth in the unused aeration tank and in both of the clarifiers. The algae growth can be seen by green layer of thick blankets floating on the top of the tanks. The algae growth in the clarifier may be due to high ammonia and phosphorus which contribute to its growth. The return sludge from the clarifier to the aeration tank may be not adequate to maintain the desired sludge age. Therefore, there is no nitrification process achieve in the anoxic zone. In the beginning of the study, a 30 minutes settleability study indicates that there is only 39.17 ml/g biomass in a liter of water. The recent MLSS value for the aeration tank is about 33.33 mg/l which is way below the targeted 2500-4000 mg/l. The low value of MLSS indicates that there are not enough bacteria for the system to decompose organic matters. Therefore, it is essential to increase the MLSS to provide more bacteria for the system.

1.3 Objectives

The objectives of the study are:

i. To evaluate the performance of aeration and clarifier tank of UTP sewage treatment plant. The evaluations are aimed to increase the current quality of effluent discharge by the treatment plant.

ii. To control the discharge of sludge and the amount of return activated sludge to achieved at least 2000 mg/l of MLSS in pilot plant.

iii. To determine the impact of segregated chemical waste from chemical block 4 and 5 on the performance of the STP using the pilot plant.

CHAPTER 2

LITERATURE REVIEW AND THEORY

UTP's new Sewage Treatment Plant (STP) was designed by Pakar Management Technology (M) Sdn Bhd. Recently, UTP employed Loyal Wastewater Engineering Sdn Bhd for operating and maintaining the STP. The design flowrate of the STP was for 23,000 population equivalence or 5,175.00 m^3/d (assuming 1 person give 225 liter output). The incoming or influent of raw sewage was assumed to consist of 250 mg/l BOD and 300 mg/l of TSS. The treated effluent out of the treatment plant was design for 10 mg/l for BOD and 20 mg/l for TSS. The system used for the treatment plant is Extended Aeration Activated Sludge (EAAS) as described in the guideline for developers issued by Director General of Sewage Services (DGSS). The treatment plant should be capable of treating or processing BOD to a standard better than 20 mg/l and 50 mg/l of suspended solids (Effluent quality of standard A). The STP was designed for a hydraulic loading of 225 l/pe/d, an organic loading of 55 g/pe/d and sludge age of 40 days.

Figure below show the flow diagram of STP:

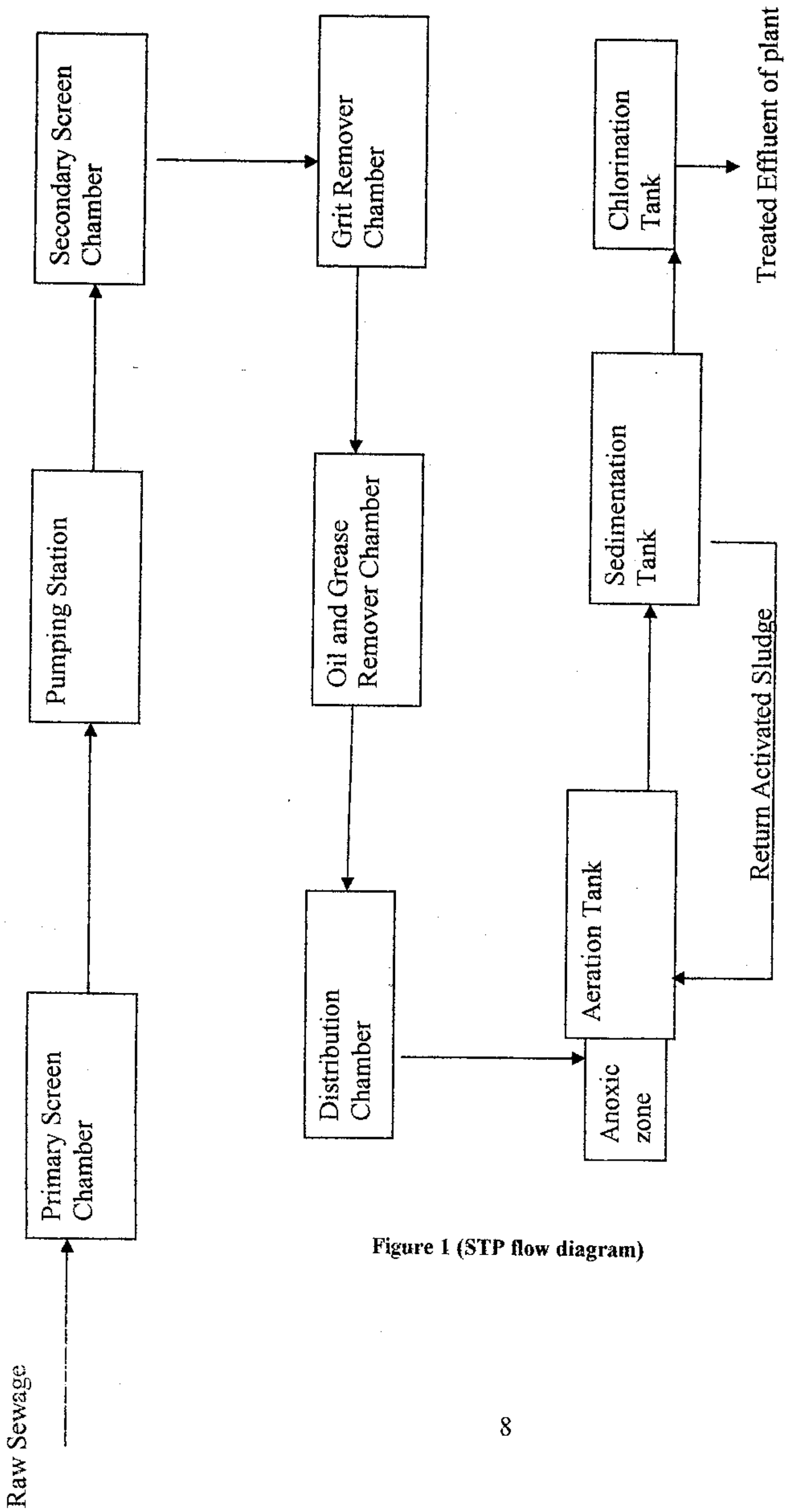


Figure 1 (STP flow diagram)

2.1 Process Description of UTP Sewage Treatment Plant

The first unit in the treatment operation is a primary screen. All wastewater entering the treatment plant will be channeled by gravity to the sump where stainless steel screen installed in order to trap unwanted large materials (15 mm spacing). Two types of screen are provided. Mechanical screen installed in a parallel with a manual screen. The manual screen will serve as a backup during the failure of the mechanized system. (STP training course by PMT Sdn. Bhd)

After the screen, the sewage flow into the sump and will be pumped up into secondary screen chamber via 6 unit of submersible pump. 4 unit of pump will be running during peak flow while the other unit serves as standby.

After pumping station, the effluent will pass 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. Two types of screens are provided. Mechanical screen was installed in parallel with the manual screen. The manual screen serves as backup during the failure of mechanized screen.

The wastewater then flow into a horizontal chamber with 10 minute detention time to remove oil and grease. The chamber equipped with oil grease channel along the side of the chamber. This channel is used to remove oil and grease draw of to the oil grease collection skip. (STP training course by PMT Sdn. Bhd)

From the grease trap, the wastewater goes to the anoxic zone. It is required by guideline for the treatment plant greater than 10,000 population equivalent to have an anoxic zone. Biological nitrogen removal is used in wastewater treatment where there are concerns for euthrophication, and where groundwater must be protected against elevated NO_3-N concentration where STP effluent is used for groundwater recharge and other reclaimed water applications. In this zone, the effluent from the aeration tank will be allowed to mix 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. The process can be represented by below equation (Gernaey, et. al., 2004):

$$NO_3 \rightarrow NO_2 \rightarrow NO \rightarrow N_2O \rightarrow N_2$$

Two modes of nitrates removals can occur in biological processes and these are termed assimilating and dissimilating nitrate reduction. Assimilating nitrate reduction involves the reduction of nitrate to ammonia for use in cell synthesis. Assimilation occurs when NH_4-N is not available and is dependent of DO concentration. On the other hand, dissimilating nitrate reduction or biological denitrification is coupled to respiratory electron transport chain, and nitrate or nitrite is used as an electron acceptor for the oxidation of a variety of organic or inorganic electron donor. The most common process used for biological nitrogen removal in a municipal wastewater treatment is Modified Ludzak-Ettinger (MLE) process (U.S. EPA 1993). Figure below show the configuration of MLE process (Metcalf & Eddy 2003):

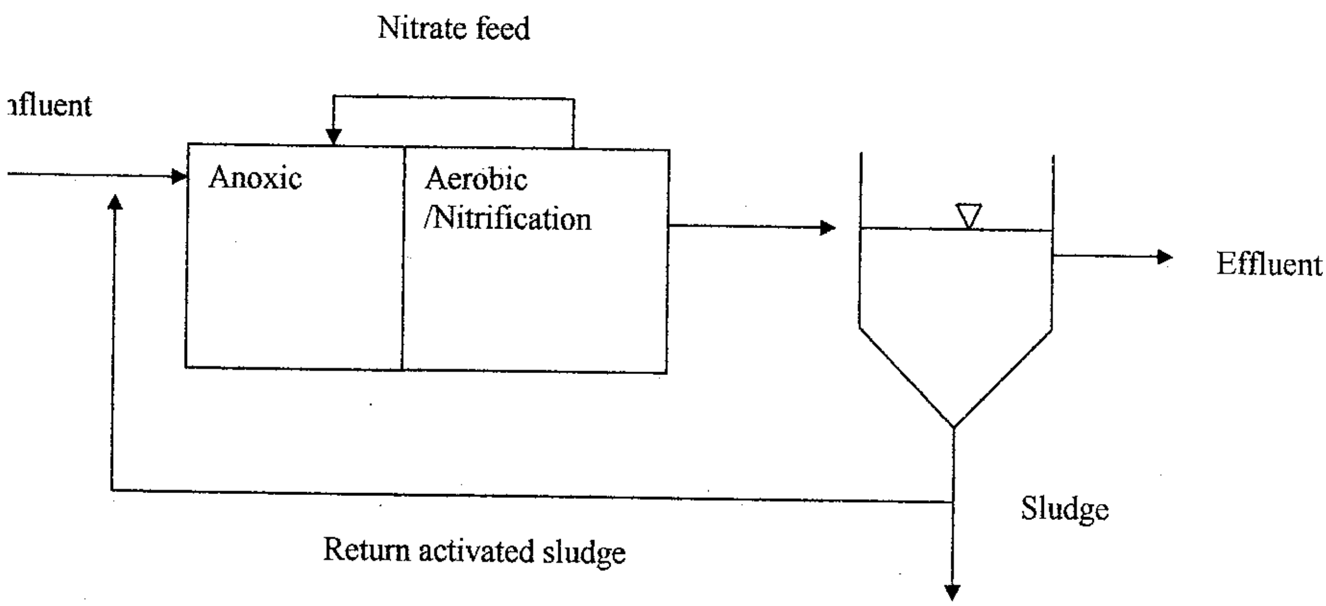


Figure 2 (Preanoxic denitrification process)

The process consists of an anoxic tank followed by the aeration tank where nitrification occurs. Nitrate produced in the aeration tank is recycled back to the anoxic tank. Because the organic substrate in the influent wastewater provides the electron donor for oxidation reduction reactions using nitrate, the process is termed substrate denitrification.

Furthermore, because the anoxic process precedes the aeration tank, the process is known as a preanoxic denitrification. (Metcalf & Eddy 2003).

Another process of denitrification is known as postanoxic denitrification. In this process, BOD removal has occurred first and is not available to drive the nitrate reduction reaction. When postanoxic denitrification process depends solely on endogeneous respiration for energy, it has a much slower rate of reaction than for the preanoxic processes using wastewater BOD. Often an exogeneous carbon source such as methanol or acetate is added to the postanoxic processes to provide sufficient BOD for nitrate reduction and to increase the rate of denitrification. Postanoxic processes include both suspended and attached growth systems. Figure below show the configuration of postanoxic processes (Metcalf & Eddy 2003):

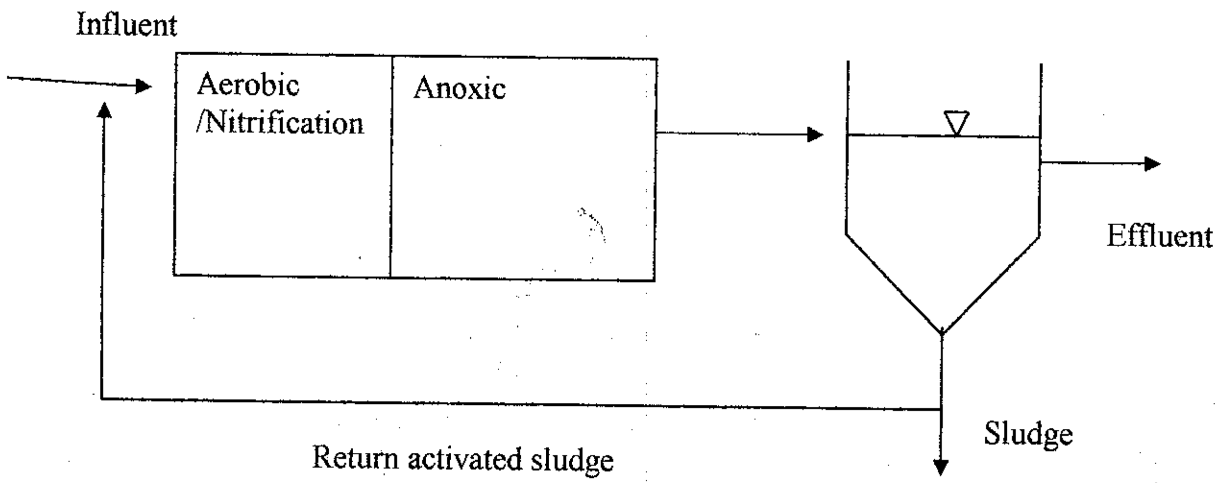


Figure 3 (Postanoxic denitrification process)

Both preanoxic and postanoxic processes described employ heterotrophic bacteria for nitrate reduction, but other pathways for biological nitrogen removal exist. Ammonia can be converted to nitrogen gas by novel autotrophic bacteria under anaerobic conditions and by heterotrophic-nitrifying bacteria under aerobic conditions. From the anoxic zone, the wastewater flow into aeration tank. The mixed liquor suspended solids (MLSS) in the aeration tank is to be maintained up to 2000-4000 mg/l. BOD will be reduced in this tank and the expected BOD reduction is over 90% (Metcalf & Eddy 2003).

Figure below simplify the nitrogen transformations in biological treatment processes (Metcalf & Eddy 2003):

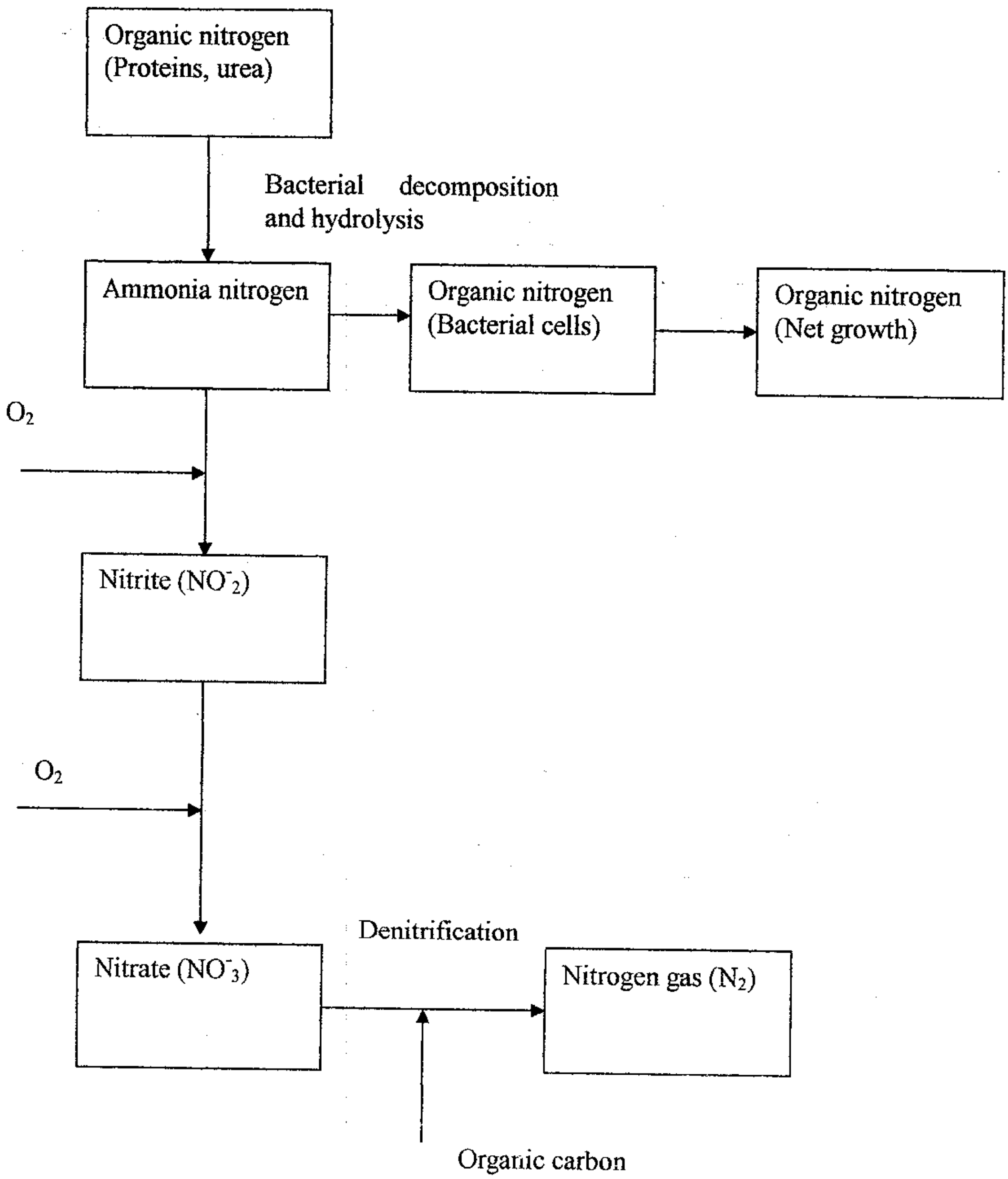


Figure 4 (Nitrogen transformation flow diagram)

The need for nitrification and denitrification process in STP arise from water quality concerns over the effects of ammonia on receiving water with respect to DO concentration and fish toxicity, the need to provide nitrogen removal to prevent euthropication and the need to provide nitrogen control for water reuse application and groundwater recharge. (Metcalf & Eddy 2003)

From the aeration tank, the wastewater will then flow into the clarifier tank for the settlement of sludge. The clear effluent is to be discharged to the municipal drain. Active sludge from the clarifier is recycled at 60 % back to the aeration tank to maintain the MLSS of the aeration tank. Some sludge has to be wasted and disposed off periodically. In order to minimize the operational cost, the sludge was thickened in the sludge thickener before thickened in aerobic digester. The sludge then pumped to the filter press/sand bed periodically (Metcalf & Eddy 2003).

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 returned back to the sump and sludge cake will be disposed at drying beds to remove remaining moisture (Metcalf & Eddy 2003).

The flow diagram of sludge dewatering facilities is shown below (Metcalf & Eddy 2003):

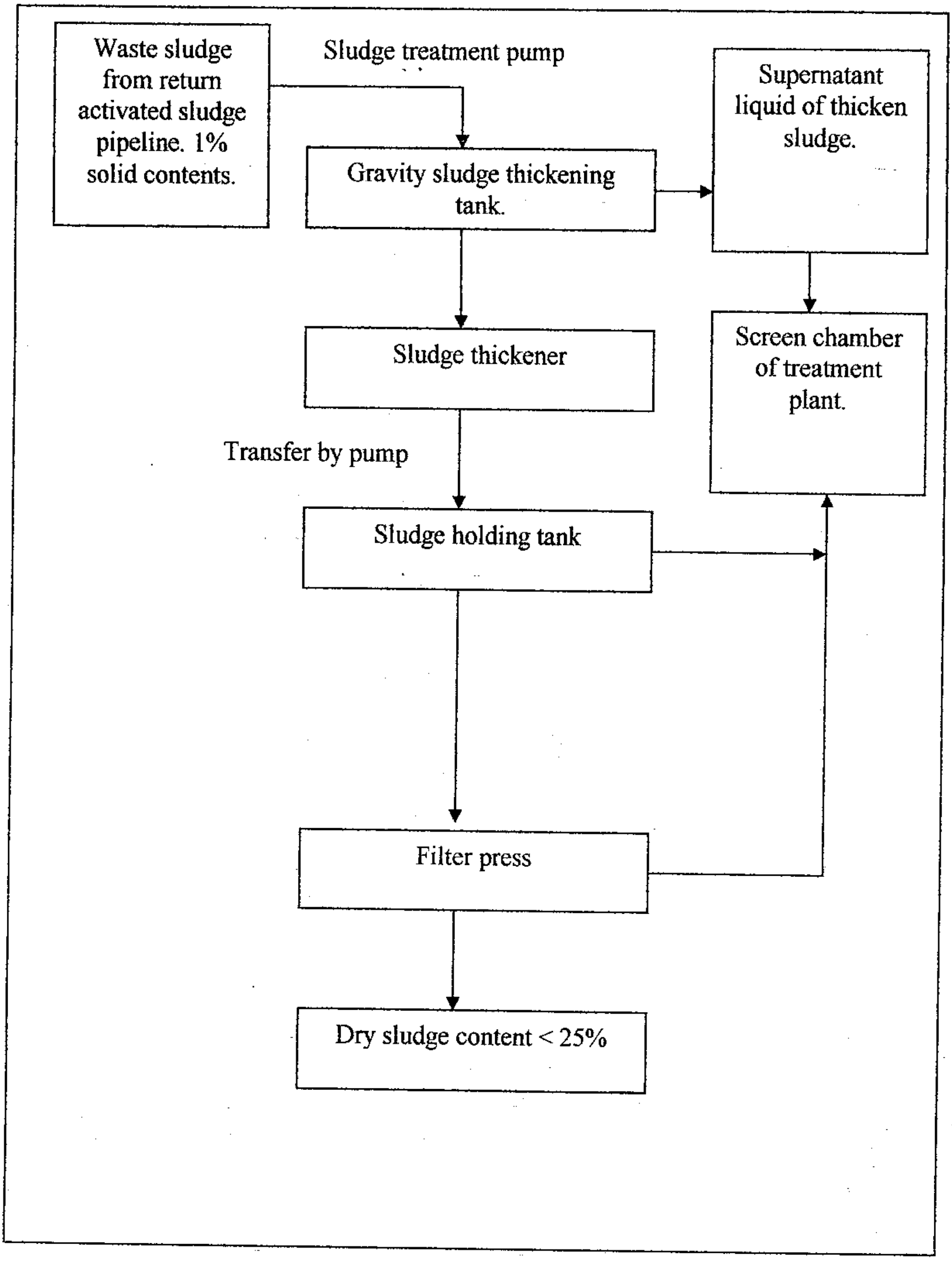


Figure 5 (Sludge dewatering flow diagram)

2.2 Activated Sludge Parameters

In order to evaluate the STP, few critical parameters should be determined and compared to the standard value. There are three parameters considered in the study are MLSS, sludge age and food to microorganism ratio. MLSS is the amount in mg/l of suspended solids retained in the aeration tank. The value of MLSS should be maintained within the range of 2000 mg/l – 4000 mg/l in order to allow the growth of bacteria in the aeration tank. Food to microorganism ratio or F/M can be calculated by (Metcalf & Eddy 2003):

$$F/M = \frac{\text{Aeration tank influent BOD or COD concentration x Influent flow}}{\text{Aeration tank volume x Biomass concentration}}$$

$$F/M = \frac{Q S_0}{VX}$$

F/M ratio is a process parameter commonly used to characterize process design and operating conditions. Typical value for BOD F/M ratio vary from 0.04 g substrate/g biomass*d for extended aeration process to 1.0 g/g*d for high rate process. F/M ratio usually evaluated for systems that were designed based on SRT to provide a reference point to previous activated sludge design and operating performance (Puteh, et. al.,1999).

Solid retention time or SRT or sludge age represent the average period of time during which the sludge remains in the systems. SRT is the most critical parameter for activated sludge design as SRT affects the treatment process performance, aeration tank volume, sludge production, and oxygen requirements. For BOD removal, SRT may vary from 3 to 5 days, depending on MLSS temperature. Table below show the minimum SRT ranges for activated sludge treatment (Metcalf & Eddy 2003).

Treatment Goal	SRT range in days	Factors affecting SRT
Removal of BOD in domestic wastewater	1-2	Temperature
Conversion of particulate organics in domestic wastewater	2-4	Temperature
Develop flocculent biomass for treating domestic wastewater	1-3	Temperature
Develop flocculent biomass for treating industrial wastewater	3-5	Temperature / compounds
Provide complete nitrification	3-18	Temperature / compounds
Biological phosphorus removal	2-4	Temperature
Stabilization of activated sludge	20-40	Temperature
Degradation of xenobiotic compounds	5-50	Temperature/specific bacteria/compounds

Figure 6 (SRT ranges and factors)

Generally, diagram below show the process and parameter to be determine throughout project:

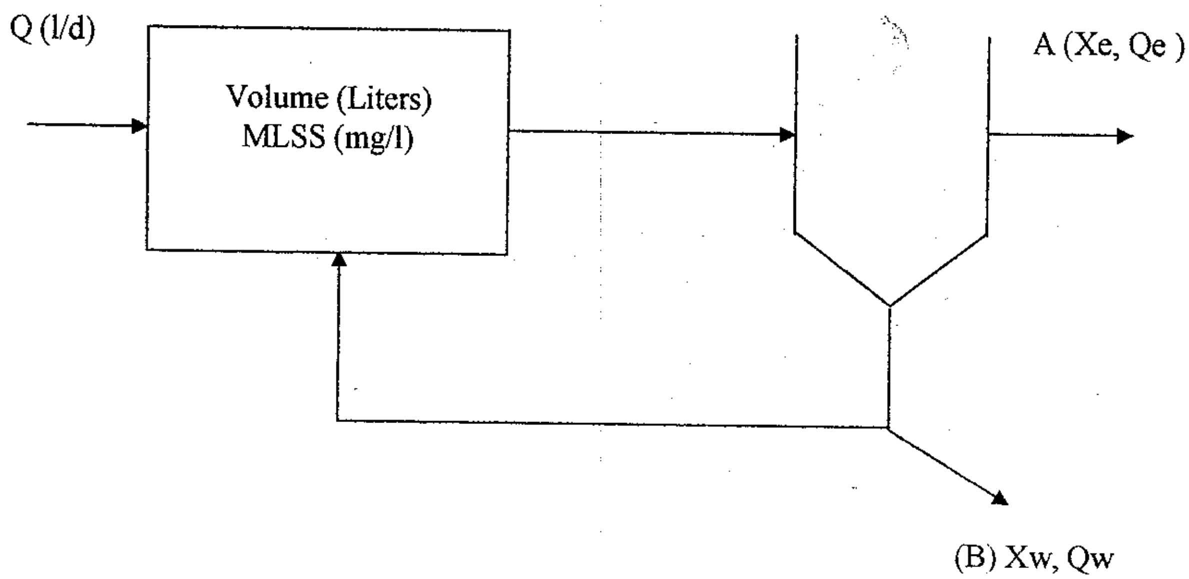


Figure 7 (SRT diagram)

The sludge age or denoted by θc is measured by days. The formula of θc is:

$$\text{Sludge age } \theta c = \frac{\text{Weight of biomass in reactor (in g @ mg)}}{\text{Sludge wasted per day}}$$

$$= \frac{\text{MLSS x V}}{\text{A + B}}$$

Where Q = flowrate in m^3/d

V= volume in m^3

X_e= concentration of biomass in effluent in g/m^3

X_w= concentration of biomass to be wasted

The volume of aeration tank and flowrate of the influent to the reactor are the parameters to be determined in order to determine the amount of sludge waste per day for a chosen sludge age at 4000 mg/l MLSS. The flowrate of effluent and influent can be measured using Electromagnetic Flow Metal (Model 801). The design BOD for the treatment plant is 20mg/l and 50mg/l for total suspended solids. This value can be calculated using below formula (Metcalf & Eddy 2003):

$$Q\ (m^3/\text{day}) \times \text{TSS/BOD (mg/l)} \times 10^{-3} = \text{BOD/TSS loading (kg/day)}$$

To maintain a high level of treatments performance with the activated sludge process under a wide range of operating conditions, special attention must be given to process control. The principal approach to process control are maintaining dissolved oxygen levels in the aeration tanks, regulating the amount of return activated sludge (RAS) and controlling the waste activated sludge (WAS). The parameter used most commonly for controlling the activated sludge process is SRT. The mixed liquor suspended solids (MLSS) concentration may also be used as a control parameter. Return activated sludge is important in maintaining the MLSS concentration and controlling the sludge blanket level in the clarifier. The waste activated sludge flow from the recycle line is usually to maintain the desired SRT. Oxygen uptake rate is also measured as a means of monitoring and controlling the activated sludge process (Dincer, et. al., 2000).

Theoretically, the amount of oxygen that must be transferred in the aeration tanks equals the amount of oxygen required by the microorganism in the activated sludge system to oxidize the organic material. In practice, the transfer efficiency of oxygen for gas to liquid is relatively low so that only small amount of oxygen supplied is used by the microorganism. When oxygen limits the growth of microorganism, filamentous organism may predominate and the settleability and quality of the activated sludge may be poor. In general, the dissolved oxygen concentration in the aeration tank should be maintained at about 1.5 to 2 mg/l in all areas of the aeration tank. Higher DO concentration (> 2.0 mg/l) may improve nitrification rates in reactors with high BOD loads. Values above 4 mg/l do not improve operations significantly, but increase the aerations cost considerably (Dincer, et. al., 2000).

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. RAS from the final clarifier to the inlet of aeration tank is essential feature of the process. Ample return sludge pump capacity should be provided in order to prevent loss of sludge solids in the effluent. The solids form a sludge blanket in the bottom of the clarifier, which can vary in depth with flow and solids loading variations to the clarifier. At transient peak flows, less time for sludge thickening is available so that the sludge blanket depth increases. Sufficient return sludge pumping capacity is needed, along with sufficient clarifier depth (3.7 to 5.5 m), to maintain the blanket below the effluent weirs. Return sludge pumping rates of 50% to 70% of the average design wastewater flowrate are typical, and the design average capacity is typically of 100% to 150% of the average design flowrate. Return sludge concentration from secondary clarifiers range typically from 4000 to 12,000 mg/l. Several techniques are used to calculate the desirable return sludge flowrate. Common control strategies for determining the return activated sludge flowrate are based on maintaining either a target MLSS level in aeration tanks or given sludge blanket depth in the final clarifiers. The most commonly used techniques to determine return sludge flowrate are settleability, sludge blanket level control, secondary clarifier mass balance and aeration tank mass balance. (Metcalf & Eddy 2003).

To maintain a given SRT, the excess activated sludge produced each day must be wasted. The most common practice is to waste sludge from the return sludge line because RAS is more concentrated and requires smaller waste sludge pumps. The waste sludge can be discharged to the primary sedimentation tanks for co-thickening, to thickening tanks, or to other sludge thickening facilities. An alternative method of wasting sometimes used is withdrawing mixed liquor directly from the aeration tank or the aeration tank effluent pipe where the concentration of solid is uniform. The waste mixed liquor was then being discharged to a sludge thickening tank or to the primary sedimentation tanks where it mixes and settles with the untreated primary sludge. The actual amount of liquid that must be pumped out to achieve process control depends on the method used and the location from which the wasting is to be accomplish. Also, because the solids capture of the sludge processing facilities is not 100%, and some solids are returned, the actual wasting rate will be higher than the theoretically determined value (Sotirakou, et. al., 1999).

Routine microscopic observations provide valuable monitoring information about the condition of the microbial population in the activated sludge process. Specific information gathered includes changes in floc size and density, the status of filamentous organism growth in the floc, the presence of *Nocardia* bacteria, type and availability of higher life forms such as protozoans and rotifers. Changes in these characteristics can provide an indication of changes in the wastewater characteristics or on operational problems. A decrease in protozoan population may be indicative of DO limitations, operation at a lower SRT, or inhibitory substances in wastewater. Early detection of filamentous bacteria or *Nocardia* growth will allow time for corrective action to be taken to minimize the potential problem associated with the excessive growth of these organisms (Metcalf & Eddy 2003).

BOD is one of the important parameter measured in order to determine the performance of the STP. In aeration tank, portion of waste is oxidized to end products to obtain energy for cell maintenance and synthesis of new cells. Simultaneously, some of waste is converted into new cell tissue using part of the energy released during oxidation. Finally, when organic matter is used up, the new cells begin to consume their own cell tissue to obtain energy for cell maintenance. This is also called as endogenous respiration. The processes can be described by chemical reactions (Metcalf & Eddy 2003):

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 tissue)

Endogenous respiration

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

Note that COHNS represent the elements of carbon, oxygen, hydrogen, nitrogen, and sulfur which is representing organic waste and $C_5H_7NO_2$ (Propose by Hoover and Porges 1952) representing cell tissue. BOD of the samples is the difference in dissolved oxygen concentration values, measured in milligrams per liters, divided by the decimal fraction of the samples used. The computed BOD value is known as the 5 days at 20^0C biochemical oxygen demand. The organisms contained in the effluent from primary sedimentation unit or facilities are used commonly as seed for BOD test. Seed however, can also be obtained commercially. When the samples contain large population of microorganism (untreated wastewater) seeding is not necessary. The standards incubation period is 5 days at 20^0C but the longer period than this can also be applicable. Longer time period such as 7 days can be used in correlations with work schedules. Therefore in this project, either 5^{th} day BOD or 7^{th} day BOD is being used. Despite of varying the incubator periods, the temperature is kept constant for both 7^{th} day and 5^{th} day BOD measurement. Different result will be obtained if the temperature is varying. This is because of the different bacteria metabolism at different temperature (Metcalf & Eddy 2003).

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

$$SVI = \frac{(\text{settled volume of sludge, mL/L})(10^3 \text{ mg/g})}{(\text{suspended solids, mg/L})} = \frac{mL}{g}$$

For example, a mixed liquor sample with a 3000 mg/L TSS concentration that settles to a volume of a 300 mL in 30 minutes in a 1 liter cylinder would have an SVI of 100 mL/g. a value of 100 mL/g is considered a good settling sludge (SVI values below 100 are desired). SVI values above 150 typically associated with filamentous growth (Metcalf & Eddy 2003).

2.3 Modelling of Activated Sludge Treatment Plant

In order to treat the domestic and industrial wastewater, the activated sludge process has been the most commonly used. It is considered to be the most cost-effective way to remove the organic materials from wastewater. Besides that, it is very flexible and can be adapted to almost any type of biological wastewater treatment problem. The design and operation of the treatment processes, however, have not been elucidated. They are highly empirical and accurate description of the performance of activated sludge wastewater treatment processes is still difficult. In most previous studies, an ideal mixing approximation, the perfect mixing model or the plug flow model, has been used to model mixing in aeration tanks. Little work deals with imperfect or actual mixing in aeration tanks. In most of them, the mixing model used to represent imperfect and actual mixing is an axial dispersion model which contains one parameter, the axial dispersion coefficient, characterizing the deviations from ideal mixing. It should be noted that the axial dispersion model is a kind of modification of the plug flow model and therefore can represent satisfactorily only mixing which deviates not too largely from the plug flow mixing (Puteh, et. al., 1999).

Furthermore, a set of differential equations and boundary conditions obtained for the axial dispersion model has to be solved by rather complicated numerical techniques. The extension of the axial dispersion model to more complicated mixing is very difficult. On the other hand, a tanks-in-series model used in this work is applicable to the whole mixing extents including perfect mixing and plug flow mixing. Moreover, the tanks-in-series model provides a set of non-linear algebraic equations, which can be solved using rather simple numerical techniques. In the tanks-in-series model, a modification for the micro-mixing or back-mixing into the model can be accomplished simply by introducing back flow which causes no difficulty in solving the equations. Therefore, the tanks-in-series model is more rational and usable as compared with the axial dispersion model. In order to design and operate an activated sludge wastewater treatment system efficiently, it is necessary to understand the role of the microorganisms to decompose the organic waste and to form a satisfactory floc, which is a prerequisite for the effective separation of the biological solids in the settler. Even though excellent floc formation is obtained, the effluent from the system could still be high in biological solids as a result of poor design of the secondary settler and poor operation of the aeration tank. The performance of the secondary settler is sometimes crucial for achieving the effluent quality required. Therefore, to discuss the overall performance of a wastewater treatment process, not only an aeration tank but also a settler must be examined (Puteh, et. al., 1999).

In this paper, the overall performance of the activated sludge wastewater treatment process consisting of an aeration tank and a secondary settling tank has been discussed from the viewpoints of the mixing in the aeration tank, the variation of BOD in aeration tank, influent, effluent and the Mixed Liquor Suspended Solids (MLSS). A tanks-inseries model has been used to consider incomplete or actual mixing in the aeration tank besides the ideal mixing conditions. The flowrate for the pilot plant was determined from $Q = V/t$.

2.4 Activated Sludge Process Under Variations of Wastewater Flow

Wastewater flow is one of the most important parameters that determine the design and operation of the activated sludge process. It affects the retention time in the plant, the food to microorganisms (F/M) ratio, the performance of the plant, the sludge blanket height in the secondary clarifiers, the sedimentation process in the primary sedimentation tanks and in general all the hydraulic and operational parameters (Metcalf and Eddy1991). For these reasons, special attention has been given to the operation and manipulation of the wastewater treatment plants (WWTPs), under high hydraulic load and shock conditions mainly because of the deterioration of the wastewater effluent quality, especially in terms of increased effluent suspended solids concentrations. In most of these studies combined sewer systems (rainwater is transferred to the WWTP together with the wastewater) are studied and different operation alternatives are tested for their ability to overcome the problems arising from the hydraulic overload event (Giokas, et. al., 2002). However, the seasonal variation of the flow to the WWTP is not the case when only combined sewer systems are used. In many cases the variation in the water consumption is the main cause for these differences. Moreover, a leak-free network is not a realizable technical or economic objective and a low level of wastewater loss cannot be avoided, even in the best operated and maintained systems. As a consequence, infiltration of water to the sewer system has been observed especially during periods of strong rainfall, depending on the level of the water horizon and the impermeability of the sewer structure. Under dry weather conditions on the other hand (mainly during the summer period), losses from the sewage network may be observed especially in dry and penetrable soils (Giokas, et. al., 2002). In general, the actual quantity of wastewater that is lost or flows into the sewage system will vary depending upon factors such as topography, length of mains, number of connections, flow rates and standards of service; depending on the cause, difficulties or slow peak flows may be observed (Giokas, et. al., 2002).Although, several reasons related to hydraulic or mass load shocks during the treatment of wastewater from combined sewer systems necessitate the thorough investigation of this operation, the variation of wastewater flow in separate sewage systems can display a very dynamic behavior and their contribution to the total flow of the sewerage network can be important even on an hourly basis (Giokas, et. al., 2002). These uncontrolled conditions also cause noticeable differences in the input flow to the wastewater treatment facilities with consequent effects on the performance and operation of the process (Giokas, et. al., 2002). For this reason, the evaluation of a plant performance is usually divided into wet and dry flow conditions, as different operational characteristics (physical, chemical or biological), affected by the inflow rate of the raw wastewater, determine the operation of the plant (Metcalf and Eddy 2003).The recognized importance of peak flow rates in the treatment of wastewater led Belhadj et al. (1995) to develop a model to simulate infiltration and its relationship with rainfall seasons based on classical hydrological modeling. The effect of peak flow rate induced during rainfall on the operation and performance of the secondary settling process has also been addressed (Mussati, et. al., 2002). However, little attention has been given to the conditions of BOD within the system and the microorganism affecting the biological process within aeration zone.

2.5 Performance Analysis of Nitrogen Removals

Wastewater streams containing nitrogenous compounds may cause serious environmental problems if they are not suitably cleaned prior to discharge into the receiving water bodies. A too high nitrogen concentration in the receiving waters can lead to eutrophication, i.e. algal outbreaks and/or fish death in rivers, lakes, and coastal areas. Nitrogen (N) may appear in wastewater in four main forms: as organic, ammonium, nitrite, and nitrate N. However, the predominant N fractions in municipal wastewater are organic N, e.g. linked to proteins present in the wastewater, and ammonium N. Before its discharge into the receiving waters, N can be removed from the wastewater by a combination of various biological processes that can take place under anaerobic, aerobic, and/or anoxic conditions. In the first step of the biological N removal process of activated sludge systems, the organic N fraction is converted to ammonium due to hydrolysis of proteins and other organic matter fractions containing N. Ammonium is subsequently oxidized to nitrate. The latter process, referred to as nitrification, takes place under aerobic conditions. Nitrogen can finally be removed from the wastewater by reducing the nitrate to N2 gas, which is released to the atmosphere. This process is commonly referred to as denitrification, and requires anoxic conditions to proceed, as well as the presence of a readily biodegradable organic carbon source. The stringent effluent limits imposed have resulted in research towards both improved design and optimized process operation of the activated sludge wastewater treatment plants (WWTPs).

Indeed, in practice there exists a wide variety of hydraulic plant configurations and operation modes for the activated sludge process. For example, there are continuous, semi-continuous, and batch activated sludge plants in full-scale operation, where the continuous process type can be considered the most conventional type. Modeling and simulation are important tools for generation and assessment of scenarios related to WWTP design and operation, aiming at minimization of the total wastewater treatment cost for a given load scenario. In that sense, a lot of basic research first focused on the understanding of the biological activated sludge mechanisms, and resulted in a number of mathematical models to describe biological N removal in activated sludge processes. The Activated Sludge Models No. 1 (ASM1) (Gernaey. et. al., 2004) presently the most widely accepted models for description of biological N removal processes.

The main differences between these two models were investigated for both steady state influent conditions and ideal disturbance scenarios. In addition to the models, several performance indexes and criteria have been proposed during the past years to evaluate the wastewater treatment system performance. The European Cooperation in the field of Scientific and Technical Research (COST) provides criteria to evaluate the effluent quality and operating costs. Vanrolleghem and Gillot (2001) included specific cost factors for aeration and pumping energy demand, waste sludge treatment, and effluent fines based on Belgian regulations. Recently, Hopkins et al. (2001) proposed a flexibility index as a tool for comparison between continuous versus batch activated sludge plant design and operation performance. The purpose of this paper is to evaluate and compare the performance of an activated sludge nitrification and denitrification by using pilot plant (model) as an indicator for UTP's WWTP's.

2.6 Pilot Plant Overview

The activated sludge pilot plant consists of an oxidation tank (aeration tank), a decanter (clarifier) and a final chlorination tank, demonstrating the traditional single stage sewage treatment process. The oxidation and mixing of the biomass is achieved through the air supplied by the small compressor. The treated liquid is sent to decantation through a restrictor. The sludge gathering at the bottom of the decanter is recirculated in the oxidation reactor and the excess fluid is automatically drained. The water, on leaving the tank, is chlorinated and discharge to the drain. Process control, supervision and data acquisition are automatically carried by means of a microprocessor regulator and specific control and supervision software which allow the remote control of the different operational parameter. The picture below shows the pilot plant:

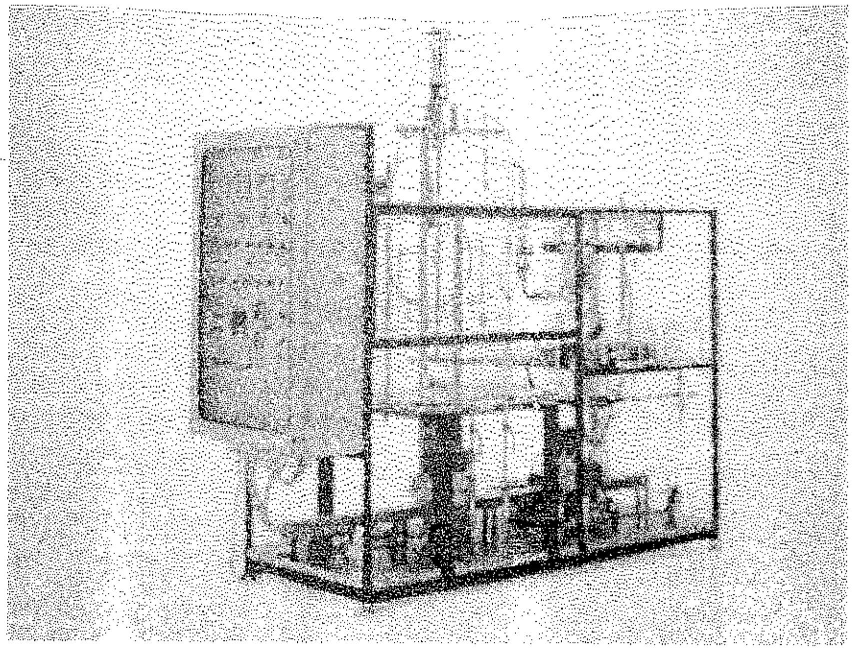


Figure 8 (Pilot plant)

2.7 Problem Encountered

Below are the problems encountered during study period:

i. Transportations problems. The UTP lorry from UTP's Maintenance Department was unavailable at most of the time. Therefore, the feeding of wastewater was really hard to be done.

ii. Because of there was no lorry to transport the wastewater, the used of student's own transport was the alternative. Due to this, the road access to Chemical Block was commonly blocked by security because there was no student's vehicles are allowed to use the road.

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

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

v. The pilot plant feeder pump usually blocked by sludge from feeder tank because there was no filter in the pilot plant system.

vi. Unavailable of laboratory equipment such as COD laboratory equipment, insufficient BOD bottles, stirrer and BOD pillow.

2.8 STP's Problems

From the observations and discussion with the engineer and work force in charge of the STP, few problems were identified in the STP. Pictures below show the problems in the STP.

i. The malfunction of the scrapper's turbine for both of the clarifiers

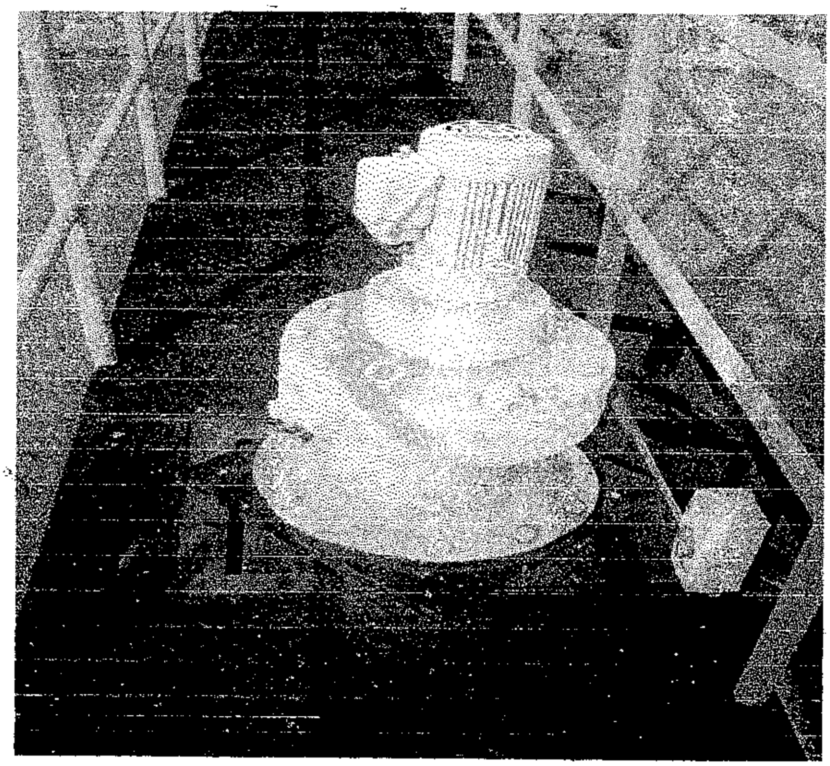


Figure 9 (Turbine)

ii. Malfunction of rotating grit chamber (to filter wastewater)

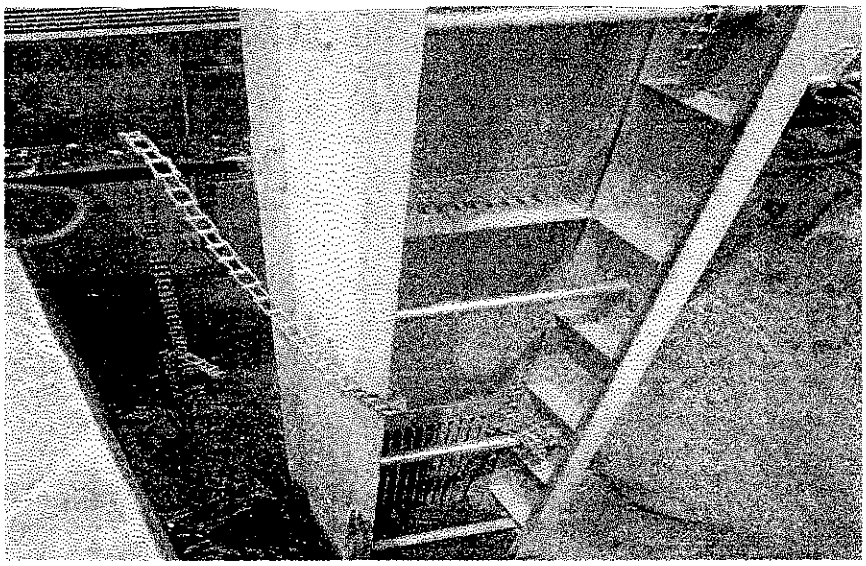


Figure 10 (Grit Chamber)

iii. Insufficient height of the inlet chamber in the primary grit chamber

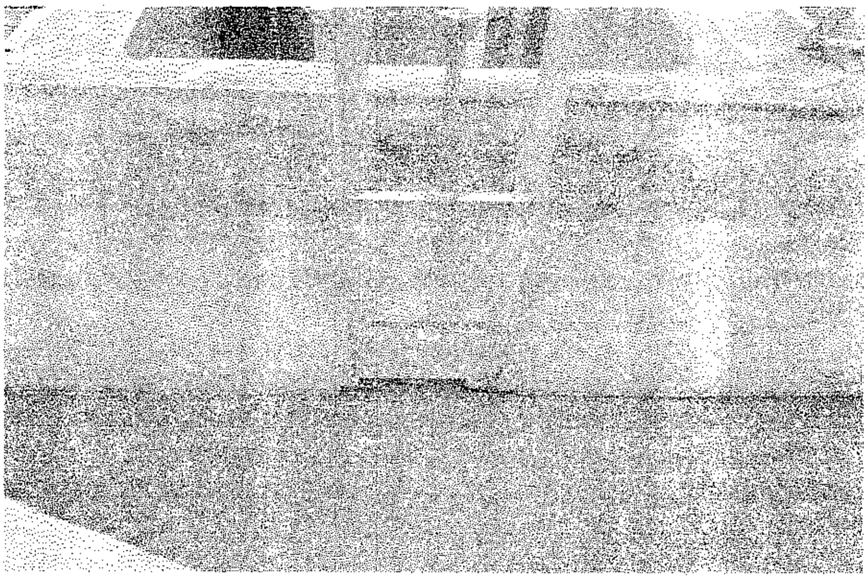


Figure 11 (Inlet Chamber)

iv. Algae growth in the clarifiers

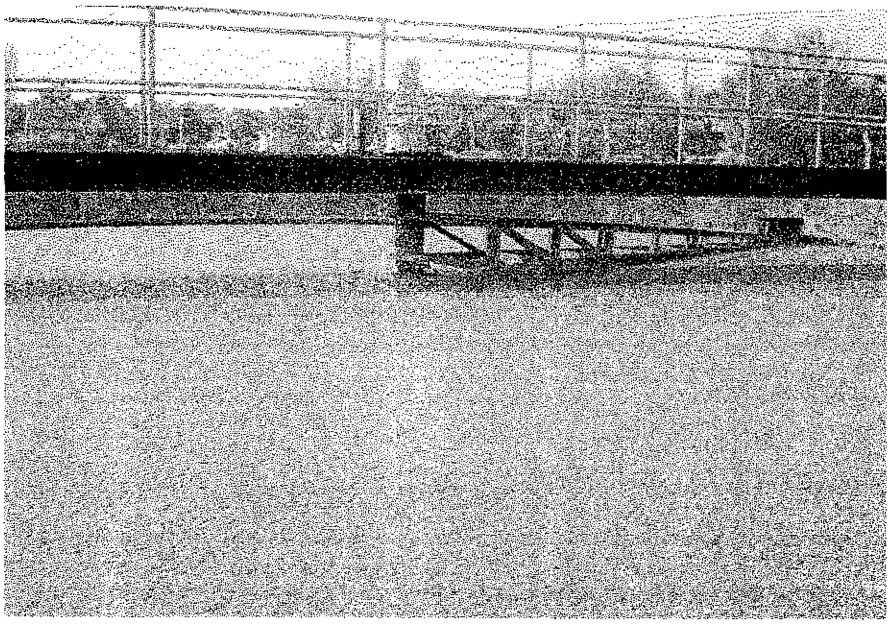


Figure 12 (Clarifier)

v. Large particles in the aerations tank due to malfunction of grit chambers

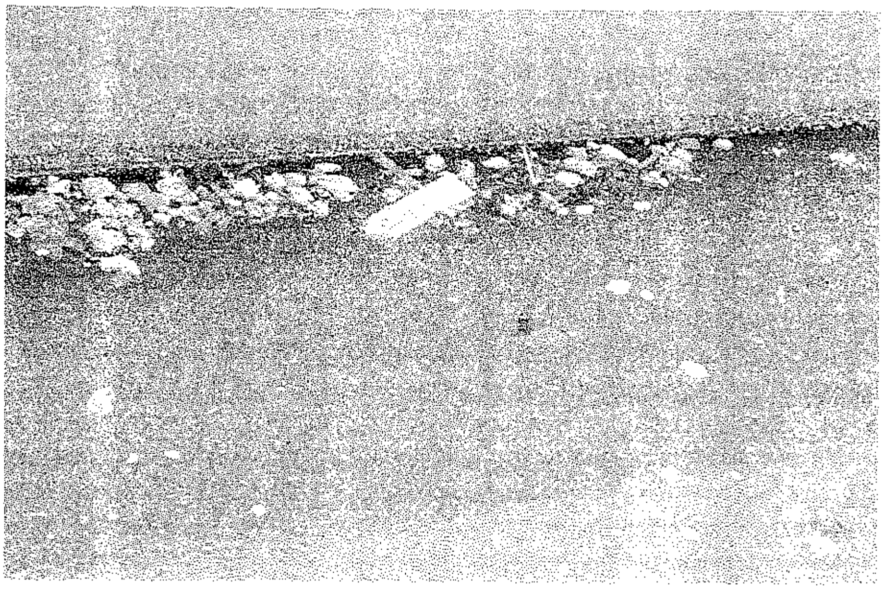


Figure 13 (Particles in Aeration Tank)

vi. The center baffle of the clarifiers were sunk

vii. Return Activated Sludge pump (RAS) were malfunction. Hence, there was no sludge returned from the clarifier to the aeration tank.

CHAPTER 3

METHODOLOGY

In order to evaluate aeration and clarifier tank, parameters such as, MLSS, BOD and SVI from both STP and pilot plant must be determined and compared. The samples were collected from two points. Point 1 is from the aeration's inlet and point 2 is from clarifier's effluent. The figure below shows the sample collection points in the pilot plant:

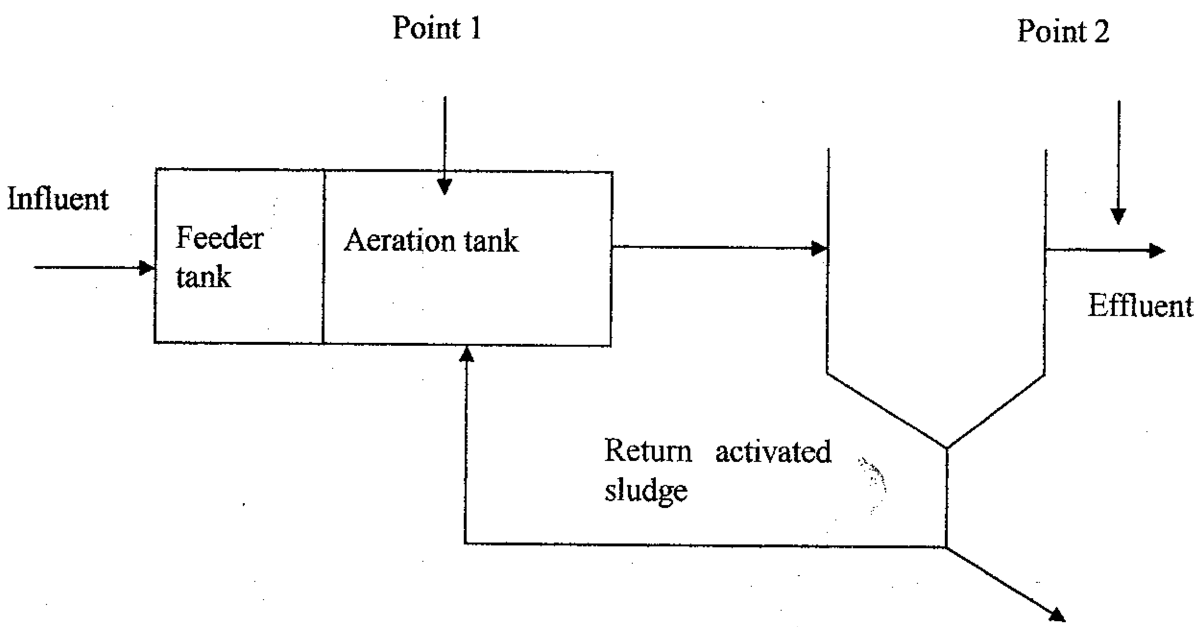


Figure 14 (Sample points)

Samples were taken from the collection points are to be tested on site using 30 minutes settleability test or SVI. The same samples were then test of BOD in the laboratory. The samples were collected twice a week. Before the commencement of any tests, the pilot plant must be feed daily in order to maintain the existence of bacteria within the aeration tank.

The study period was divided into two parts. In the first period (first five weeks) the pilot plant is run exactly based on STP's current condition. To achieve the exact condition like STP, the MLSS pump was shut down, so there is no return activated sludge from clarifier to aeration tank. The water in the aeration tank of pilot plant was from STP's aeration tank and the clarifier tank of the pilot plant was filled with water from STP's clarifier. Feeder for aeration tank was collected from STP's anoxic zone.

For the second period (last five weeks), the MLSS pump was allow to circulate within the system. With sludge recirculation, the pilot plant will operate normally. The additional sludge from oxidation pond was then added into the system to encourage bacteria growth.

The comparison between these two operational systems is done by comparing BOD results, types of bacteria existed, ammonia removals efficiency, pH, and the turbidity of the effluent.

For the last 5 weeks, segregated chemical waste from chemical blocks 4 and 5 are added into the feeder tank along with normal wastewater. The segregated chemical waste consists of 20% of feed wastewater. The objective of adding the segregated chemical waste is to study whether there are changes in STP effluent quality and performances if segregated chemical waste is introduced into UTP's STP.

3.1 BOD Procedures

Biological Oxygen Demand or BOD is the amount of oxygen needed for the bacteria to degrade the organic matter in the wastewater. For this experiment, only total sample being done first and soluble (need filtration first) was not done yet.

First, distilled water must be aerated for at least 24 hours before the test can be done. Then, standards are prepared using distilled water. The BOD meter was calibrated based on the manual. The samples from the bottles are poured into 500 ml beaker and stirred using stirrer. 2ml or 5ml sample from 500 ml beaker was measured using pipette and being poured into BOD bottles. The amount of sample used depend on where is the samples are taken. Larger volume for experiments needed if the samples are from effluent or it has been treated. After that, the BOD bottles were filled up with distilled water until it full. To ensure that there are no bubbles within the bottles, the distilled water must be pour slowly with tube. (The tube must not enter the bottle to avoid contaminations).

Then, using BOD meter, the initial reading of the samples is recorded. The samples in each bottle were then being put in to incubator under 20^0C and stored for 5 days. After 5 days, the bottles were taken out from the incubator and the BOD was measured (Ensure that the BOD meter was calibrated using fully aerated distilled water).

3.2 Pilot Plant Preparations

The pilot plant dimensions are 2000x900x1800mm with weight of 280 kg. The pilot plant was filled with wastewater on 19th July 2004. The feeder tank was filled with wastewater from anoxic zone, the aeration tank was filled with wastewater from aeration tank in STP while the clarifier was filled with water from STP's clarifier. The volume filled in pilot plant aeration tank was 300 liter. Picture below show the pilot plant aeration tank after it was filled with wastewater.

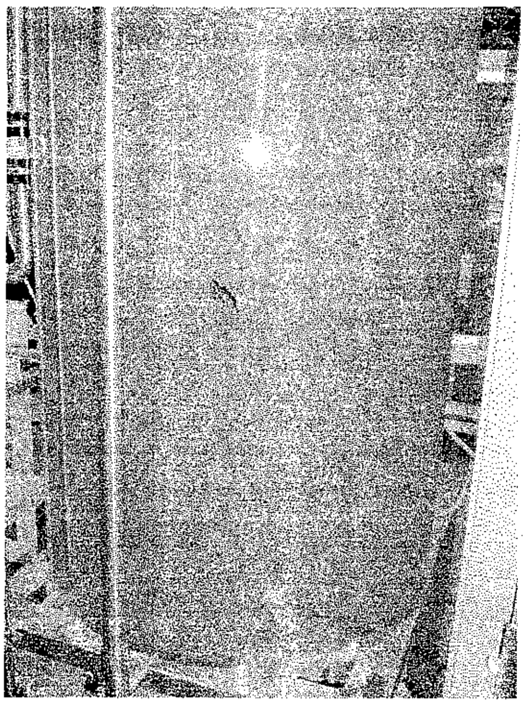


Figure 15 (Sample points)

The pilot plant was run manually and adjusted according to below specifications:

Air flowrate	600 l/h
Feed flowrate	4 l/h
V4,V5,V6,V8,V9.V10, V11,V12,V13,V3	Off
V1,V2,V7	On
Main power	220V- 50Hz

Figure 16 (Pilot plant configuration)

For the first 5 weeks of the study period, valve 3 (V3) was closed to simulate the same condition as STP (no sludge circulation in the current operation in STP). However, after 5 weeks, valve 3 will be open to allow the pilot plant operates normally, and segregated chemical waste will be introduced as an influent to the system along with normal wastewater. Table below shows the weekly feeding and sample taken from the pilot plant:

Day	Activity
Monday	Feeding Pilot Plant / Read BOD
Tuesday	Feeding Pilot Plant
Wednesday	Feeding Pilot Plant / BOD test / Read BOD
Thursday	Feeding Pilot Plant / Bacteria observations
Friday	Feeding Pilot Plant for 3 days / BOD test

Figure 17 (Weekly Activities)

CHAPTER 4

Findings and Experiments

In order to determine the value of Biological Oxygen Demand (BOD), ammonia concentration and types of bacteria exist within the Sewage Treatment Plant and Pilot Plant, series of laboratory experiment must be done. The highest value of each experiment was assumed as a final value for the experiment.

4.1 BOD Test

Six BOD tests were conducted in order to determine the performance of the treatment plant. Four tests were conducted under existing condition of UTP's treatment plant and one test was conducted under normal operation method in the pilot plant. The tests are conducted using 10 ml and 20 ml of sample volume for each point. Therefore, there are 24 bottles for one sample. Each test was conducted at 11.00 am. The results are shown in the graph below:

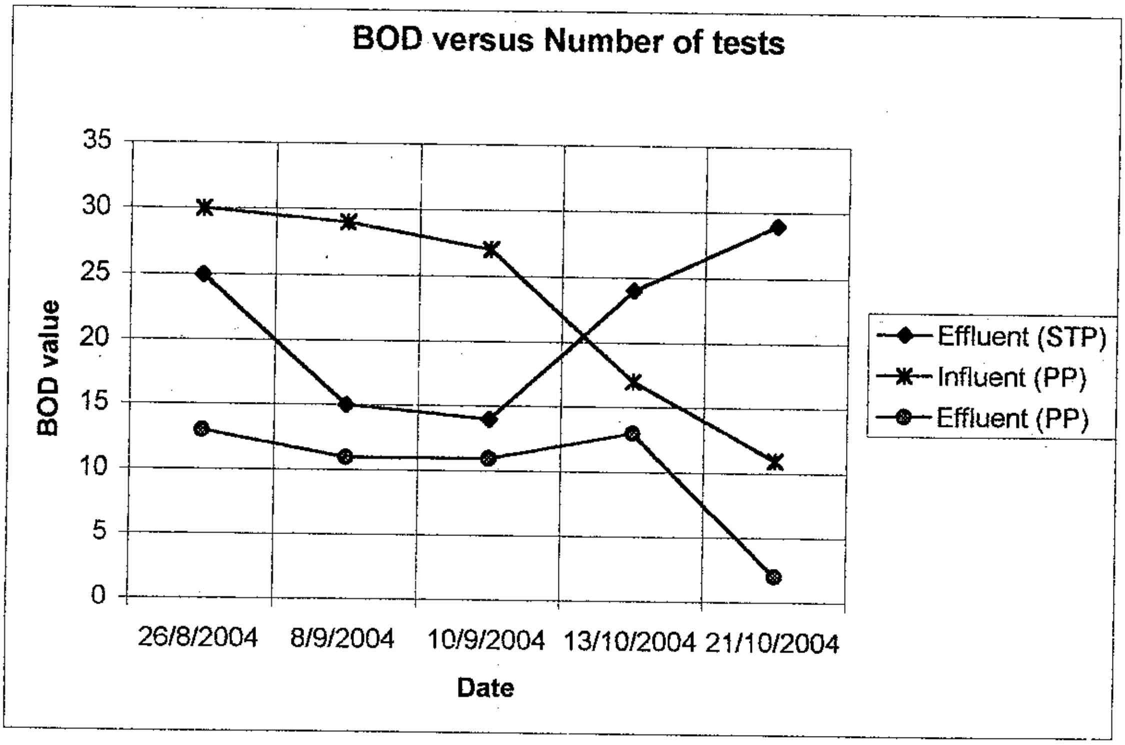


Figure 18 (BOD graph from test 2-6)

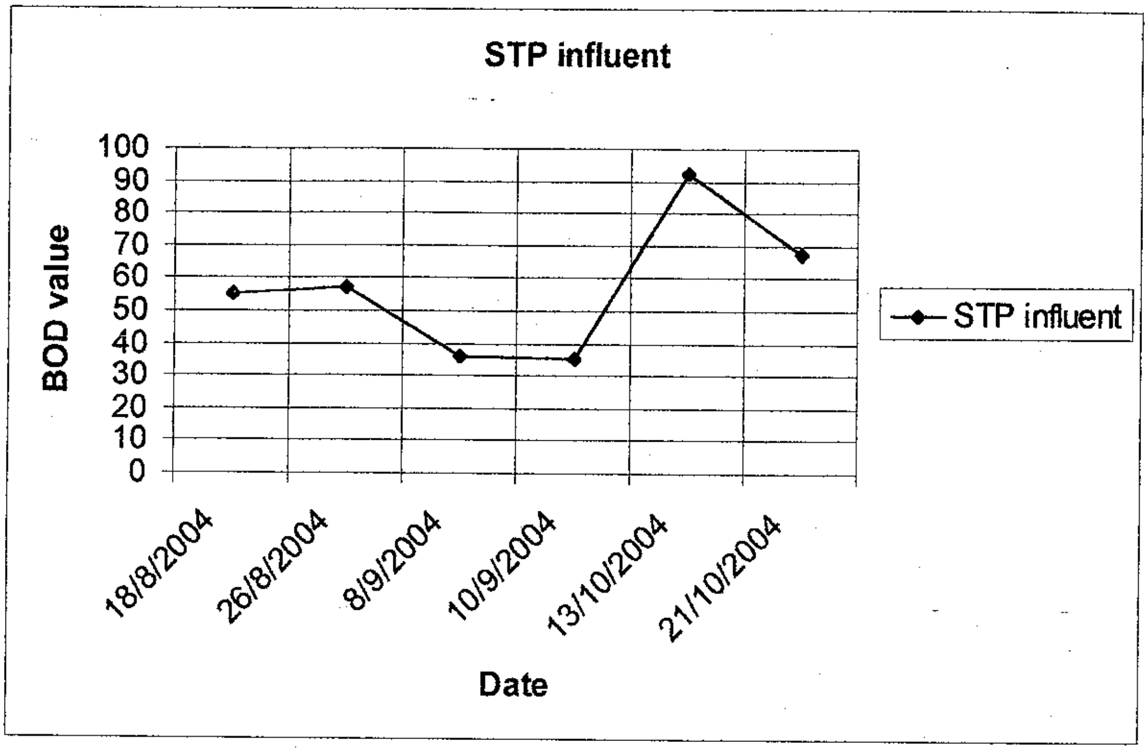


Figure 19 (Graph for STP influent from first test)

On the first test, only the influent of STP can be measured while the effluent samples cannot be taken because of bad weather condition. The influent of STP was quite constant with the highest value of BOD is 57 mg/l before wastewater from oxidation pond was diverted into STP's inlet on 2/10/2004. After the influent of oxidation pond was diverted into STP, the BOD influent increase to 92 mg/l on test 5. In spite of that, the BOD influent is still far from the requirement BOD value for STP which is 200mg/l - 250mg/l. The lack of influent BOD was probably because of the capacity size of the treatment plant is too big for small amount of influent. As stated in the design configuration, the treatment plant was constructed for 23,000 population equivalent. This might be over design because the overall population in UTP is only 8000-9000 peoples, and not all wastewater from UTP is channeled into the STP's influent. The STP only covered student residential area. Another reason is the method of influent intake to the pilot plant. The influent need to be stored in the large intake sum until it full before being pump to secondary grit chamber. Sometimes, the period of storing the wastewater influent took about 10-20 minutes before it full and can be pumped to the secondary grit chamber. Since the sum is open channel, it is possible to have oxidation process. The wastewater being oxidized while waiting to be transferred into secondary grit chamber and this can reduced the BOD value because oxidation consume and degrade the biodegradable particles in the wastewater.

The STP effluent varies from 15 mg/l to 30 mg/l from test 2 to test 6. The highest effluent measured was 29 mg/l, which the samples taken after 2/10/2004 when all the oxidation influent has been diverted to STP inlet. These results shows that all the effluents are still complied to the limit stated by DOE for Standard B (50mg/l BOD, 100 mg/l TSS) even though the process of treatment was not properly executed. The MLSS of aeration tank was approximately in ranged of 40-80 mg/l which are out of design requirement (2000-2500 mg/l). This situation is once again related to the size of aeration and clarifier tank. The huge size of aeration tank with high dissolve oxygen released to the wastewater tends to invite oxidation process to occur. The dissolve oxygen should be low and just enough to provide the bacteria with oxygen to stay alive and degrade the organic matters. However, the oxygen is being released in high concentration in the tank since there is no control panel to control precisely amount of oxygen in the tank. Therefore, with the help of large size of aeration tank, the organic matters are settled and oxidize, leaving low concentration of organic matters to enter the clarifier. In clarifier, the same process occurs and it will further reduce the BOD value. However, the flaws of the treatment process still can be seen at the clarifier where there is tremendous algae growth due to ammonia and phosphate which are failed to be broke into nitrogen through denitrification process.

The pilot plant's influents are varies in the ranged of 20-30 mg/l before the addition of chemical wastewater from chemical Blocks 4 and 5 (segregated chemical waste added after test 4 -10/9/2004). The value of influent in pilot plant drop to 17mg/l after the addition of 20% chemical waste from the total volume of influent feed into the pilot plant. It is to be noted that from test 1 to test 4, there is no sludge recycling from the clarifier to the aeration tank and there is no chemical waste added to the feeder tank. There was approximately 25% of BOD value reduction from STP influent to the pilot plant influent. This might be because of the filtration done when the wastewater was collected from the STP and before the wastewater was poured in the feeder tank at pilot plant. The filtration reduces the suspended solids in the wastewater and it will reduce the amount of biodegradable materials in the influent. However, the filtration is a must do thing to avoid the pump from getting stuck. The long process of transporting the wastewater from STP to pilot plant also effects the concentration of BOD in the feeder tank. The longer the period of water to be transported, the lower the BOD will be. This is because of the oxidation of the wastewater. The vibration during pouring and transporting the wastewater into the feeder tank also help to aerating the wastewater, hence adding oxygen for oxidation process. High oxygen concentration in wastewater will reduced the value of BOD. After the recycling of sludge and addition of chemical wastewater, the influent reduced to 17 mg/l and 11 mg/l because of the dilution of wastewater by the chemical wastewater. The chemical waste was already being segregated from hazardous chemicals component. The segregated chemical waste did not have suspended solid and it is not settled even after 2 hour of detention time. Hence, it is possible for the chemical waste to dilute the wastewater concentration and reduce it BOD. In addition, the time period of collecting and pouring the wastewater from STP to pilot plant was increase because of the collection of chemical wastewater consume much time since it cannot be pumped up to the container (each container equivalent to 25 l).

Pilot plant BOD effluent varied from 11 mg/l to 13 mg/l for second to fourth test and it increase to 13mg/l for the fifth test and decrease tremendously to 2 mg/l for the last test. To simulate the exact condition of the STP, dissolve oxygen supply in the pilot plant was increased to 6-7 mg/l daily to see whether there are effects of oxygen to the treatment processes. Before the addition of segregated chemical waste to the pilot plant, the percentage of BOD removals in the pilot plant are approximately 60-80 % reduction. However, the percentage reduces to 33 % of BOD removals in the fifth tests. These suggest that the chemical added into the wastewater has an effect on BOD treatment because it tends to reduce the effectiveness of the pilot plant treatment process. Although it may dilute the influent and reduces the BOD value of the influent, the chemicals are reducing the percentage of BOD removals in the pilot plant. However, it is necessary to observe the performance of the pilot plant for a month or more to determine whether the chemical can effect the survival of the bacteria needed in the aeration tank.

4.2 Observations

There was green algae growth in the clarifier for the first 5 weeks period where there was no return activated sludge. The existence of phosphate and ammonia in the clarifier encourage the growth of green algae. Phosphate and ammonia are the nutrient for the algae. This condition reflects well to what is happen in the STP. When there is no denitrification process occur in the system, ammonia and phosphate will stay in their current state without being reduced to nitrogen gas.

For the last 5 weeks, MLSS return pump allowed the circulation of sludge from clarifier to the aeration tank in the pilot plant. An observation shows floating sludge scatter all over the clarifier surface. This situation suggests that there maybe denitrification process because the sludge was push up by nitrogen gasses. Nitrogen gasses in treatment plant were originated from the denitrification process of ammonia. Two weeks after circulation of sludge (MLSS), there was a reduction in the green algae growth on the clarifier. Therefore, to overcome the green algae in the STP clarifier, it is important to allow the circulation of sludge so denitrification process can be achived.

CHAPTER 5

RECOMMMENDATIONS

In order to rectify the flaws in the treatment plant, the contractor must first increase the Mixed Liquor Suspended Solids (MLSS) to 2500 mg/l or above. To increase the MLSS value, return activated sludge (RAS) pump must be turned on. The RAS pump is currently switch off. The return sludge can increase the suspended solids value in the aeration tank. Therefore, the numbers of bacteria can be increase if there are enough nutrients from the waste in the aeration tank.

The clarifiers must be fixed in order to keep it function. The existing algae growth needs to be cleared off. 40 days of sludge age must be achieved to allow the degradation of ammonia in the anoxic zone. If the specified sludge age period is achieved, the ammonia can be degraded through nitrification process into nitrate and nitrite. The nitrite later on can be break into nitrogen through denitrification process with the supply of carbon (wastewater). Therefore, there is no ammonia or nitrate released into the clarifier.

To increase the efficiency of the treatment plant, the contractor must fully utilize all the facilities in the treatment plant. Filter press, grit chamber, chlorination tank, clarifier, gravity thickener which are recently not functioning must be utilize throughout the process.

The pilot plant should be placed nearer to the STP. This will allow students to use the pilot plant more effective and in an easier way, therefore process of transporting the wastewater from STP to the pilot plant can be easier. It also can save time wasting during the wastewater collection and transportation from the STP to the pilot plant.

Alternatively, UTP should provide a vehicle for Civil Department to ease the difficulty of getting the transportation (such as lorry) for research purposes.

CONCLUSION

The highest influent value for STP was 92 mg/l and the highest influent for pilot plant was 30 mg/l. The increase of BOD value in STP influent was caused by the channeling of oxidation pond influent into the STP influent. The addition of wastewater increases the influent BOD value. In spite of that, the influent BOD value is still below the requirement (200-250 mg/l). Pilot plant influent was lower than STP influent because of the oxidation process that occurred during the long feeding processes. Oxidation reduces the BOD value of wastewater. The highest effluent of STP was 22 mg/l and 11 mg/l for pilot plant. These values are still in ranged of Standard A and B stated by DOE. The effluent still meet the requirement despite of poor processes treatment of STP mainly because the concentration of dissolve oxygen supplied to the aeration tank and anoxic zone. The high concentration of dissolve oxygen encourages oxidation process to occur and reduce the BOD value. The huge sizes of aeration tank and clarifier provide more time to the organic matter to settle and being oxidized.

The addition of segregated chemical waste to the normal wastewater reduced the influent BOD by diluting it. However, it also reduced the percentage of BOD removals of pilot plant. Only 20% of segregated chemical wastewater being added into the total amount of normal wastewater feed into the pilot plant's aeration tank. The reduction of treatment efficiency after addition of chemical waste into pilot plant suggests that the chemical waste might have minor negative effects to the overall treatment processes. However, if the segregated chemical waste (from block 4 and 5) is introduced into the normal STP's activated sludge system, it still can treat and give a good effluent.

REFERENCES

1. Metcalf & Eddy, revised by Tchobanoglous, G., and Burton, F.L., (2003), *Wastewater Engineering, Treatment and Reuse,* 4^{th} Edition, Mc Graw Hill International Edition.
2. Krist V. Gernaey, Mark C.M van Loosdrecht, Mogens Henze, Morten Lind, Sten B Jorgensen, *Activated sludge wastewater treatment plant modeling and simulation: state of the art.* Environmental Modeling & Software 19 (2004) 763-783.
3. E. Sotirakou, G.Klatidis, N. Diamantis, H. Grigolopoulou, *Ammonia and phosphorus removal in municipal wastewater treatment plant with extended aeration,* Global Nest the Int. J. Vol 1, pp 47-53, 1999.
4. M.Puteh, K. Minekawa, N. Hashimoto, Y. Kawase, *Modeling of activated sludge wastewater treatment processes,* Bioprocess Engineering 21 (1999), 249-254.
5. Ali R. Dincer, Fikret Kargi, *Effects of operating parameters on performances of nitrification and denitrification processes,* Bioprocess Engineering 23 (2000), 75-80.
6. D.L. Giokas, A.G. Vlessidis, M.O. Angelidis, G.J. Tsimarakis, M.I. Karayannis, *Systematic analysis of the operational response of the activated sludge process to variable wastewater flows. (A Case Study).* Clean Techn Environ Policy, 4, (2002) 183-190.
7. Miguel Mussati, Krist Gernaey, Rafiqul Gani, Sten Bay Jorgensen, *Performance analysis of a denitrifying wastewater treatment plant,* Clean Techn Environ Policy, 4, (2002) 171-182.

APPENDICES

1. APPENDIX 1: Results of BOD tests
2. APPENDIX 2: Pictures of laboratory equipments
3. APPENDIX 3: Pictures of existing treatment plant
4. APPENDIX 4: Pilot plant pictures

APPENDIX 1: Results of BOD tests

Name : Mohd Fadly Bin Nor Azman

Title : Impact of chemical waste discharge on BOD removal in STP

<u>Work Program for July 2004 Semester (Final Year Project)</u>

No	Detail / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Research Works														
	- Gathering STP and pilot plant information														
	- Sample collection														
2	Project Works														
	-Lab test (BOD)														
	-Literature review														
	-Pilot plant preparations														
3	Submission of Progress Report 1														
4	Project Works														
	-Reference/Literature														
	-Lab test (BOD)														
	-Ammonia measurement														
5	Submission of Progress Report 2														
6	Project work continue														
	- Lab test (BOD)														
	Ammonia measurement														
7	Submission of Interim Report Final Draft														
8	Oral Presentation														
9	Submission of Interim Report														

BOD raw datasheet

18/8/2004

BOD DATA SHEET

ate			Analyzer						
nple	~~Dilution~~ Bottle ID	Vol. of Sample (ml)	Initial D.O. (mg/l)	Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
nk	150	–	8.78	8.58		0.2.			
	22	–	8.78	8.57		0.21			
	16	–	8.78	8.66		0.12 ok.			
ent	146	10	8.65	6.68			55.5		Next use 6 bottles of 10ml
tion)	20	10	8.63	6.59			57.6 ~~61.20~~	57.1	6 bottles of 20ml
	18	10	8.68	6.62			58.2		
ent	19	20	8.46	4.64			57.5		
ation)	6	20	8.45 ~~8.44~~	4.94			58.85	53.3	
	23	20	8.45	4.76			53.55		
ent									
t .									

$DO_2 - DO_1 \geq 2$ mg/l.

Final DO > 1 mg/l

STP.　　　　　　　　　　　　　　26/8/04.

BOD DATA SHEET

ate		Analyzer						
nple	**~~Dilution~~** Bottle ID	**Vol. of Sample (ml)**	**Initial D.O. (mg/l)**	**Final D.O. (mg/l)**	**Seed (ml)**	**Seed/ Blank Correction**	**BOD (mg/l)**	**Avg. BOD (mg/l)**	**Comments**
	8	–	8.74	8.05		0.69			
nk	9	–	8.74	~~8.10~~ 8.34		0.4			
	10	–	8.74	~~8.10~~ 8.35		0.4			
te	20	10	8.64	7.67			17.4		
fluent	16	10	8.63	7.62			18.6	18.1	
	7	10	8.65	7.65			18.3		
	10	10	8.64	~~7.67~~ 7.43			24.6		
uent	23	10	8.63	7.22			30.6	25.2	
	165	10	8.62	7.55			20.4		
	21	20	8.48	6.93			17.4		
ent	11	20	8.48	7.17			13.8	15.6	
	5	20	8.51	7.08			15.6		
	12	20	8.51	7.29			12.45		
ent	22	20	8.53	7.31			12.45	12.8.	
	9	20	8.48	7.19			13.5		

diff > 2.

Final DO > 1

26/8/04

BOD DATA SHEET									
e			Analyzer						
le	~~Dilution~~ Bottle ID	Vol. of Sample (ml)	Initial D.O. (mg/l)	Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
	1	10	8.50	6.04			62.1		
nt	2	10	8.51	6.38			52.2	54.1	
c)	3	10	8.5~~4~~3	6.54			48		
ut	150	10	8.50	6.48			48.9		
c)	17	10	8.51	6.01			63.3	56.7	
	18	10	8.50	6.18			57.9		
ut	153	20	8.25	4.25			54.15		
)	6	20	8.28	4.17			55.8	56.2	
	24	20	8.28	3.98			58.65		
ut	15	20	8.32	4.58			50.25		
c)	167	20	8.28	4.13			56.4	53.7	
	13	20	8.30	4.28			54.5		

Pilot Plant 26/8/2004

BOD DATA SHEET

			Analyzer						
e	~~Dilution~~ Bottle ID	Vol. of Sample (ml)	Initial D.O. (mg/l)	Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
	8	-	8.74	8.65		0.69			
	9	-	8.74	8.34		0.4			
	10	-	8.74	8.35		0.39			
	13	10	8.69	7.9			12		
J	15	10	8.64	7.82			12.9	12.6	
	77	10	8.67	7.85			12.9		
	12	10	8.7	7.94			11.1		
k	26	10	8.71	7.95			11.1	10.8	
	33	10	8.72	7.99			10.2		
	35	20	8.5	7.66			6.75		
t	36	20	8.55	7.62			8.1	7.7	
	37	20	8.56	7.62			8.25		
	1101	20	8.54	7.78			5.55		
t	1105	20	8.56	7.59			8.7	7.45	
	1109	20	8.55	7.62			8.1		

26/8/04

BOD DATA SHEET

e			Analyzer						
	~~Dilution~~ B. ID	Vol. of Sample (ml)	Initial D.O. (mg/l)	Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
	97	10	8.4	7.04			29.1		
nt	99	10	8.46	7.06			30.3	29.7	
	98	10	8.44	7.06			29.7		
	1000	10	8.56	7.19			29.4		
d	1050	10	8.51	7.22			27	27.2	
	1090	10	8.49	7.26			25.2		
	151	20	8.3	6.06			27.8		
d	153	20	8.36	6.05			28.8	27.3	
	159	20	8.4	6.32			25.35		
	225	20	8.15	6.36			21		
t	226	20	8.41	6.06			29.4	26.25	
	227	20	8.39	6.11			28.4		

ilot Plant   8/9/2004.

BOD DATA SHEET

e			Analyzer						
le	~~Dilution~~ B ID	Vol. of Sample (ml)	Initial D.O. (mg/l)	Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
nt	111	10	8.59	8.11		~~0.4~~	10.2	11	
	60	10	8.60	8.08		~~0.44~~	11.4		
	235	10	8.62	8.10		~~0.31~~	11.4		
nt	1701	10	8.56	8.13			8.7 ~~15.3~~	9.9 ~~15.3~~	
	237	10	8.58	8.05			11.7 ~~14.4~~		
	152	10	8.58	8.13			9.3 ~~16.2~~		
nt	200	20	8.54	7.75			9.75	9.8	
	241	20	8.54	7.78			9.3		
	167	20	8.54	7.71			10.35		
nt	1411	20	8.54	7.74			9.9	11.2	
	1167	20	8.56	7.63			11.85		
	271	20	8.56	7.63			11.85		
t	3	20	8.66	7.03			22.35	28.7	
	1101	20	8.67	6.53			30		
	721	20	8.66	6.27			33.75		
nt	618	20	8.57	6.79			24.6	22.6	
	821	20	8.56	7.41			15.2		
	11501	20	8.59	6.58			28.05		

ot Plant 8/9/2004

BOD DATA SHEET

e			Analyzer						
ple	Dilution	Vol. of Sample (ml)	Initial D.O. (mg/l)	Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
ent	1.65	10	8.60	7.70			22.8		
	290	10	8.63	7.53 ~~7.85~~			28.8	23.3	
	400	10	8.60	7.85			18.3		
ent	320	10	8.62	7.74			22.2		
	316	10	8.58	7.78			19.8	20.2	
	47	10	8.58	7.82			18.6		

8/9/2004

TP

BOD DATA SHEET

e			Analyzer						
ɔle	~~Dilution~~ Bottle ID	Vol. of Sample (ml)	Initial D.O. (mg/l)	Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
	5	-	8.70	8.36		0.4			
	* 8	-	8.70	8.56		0.14			
	150	-	8.70	8.39		0.31			
	153	10	8.68	8.03			15.3		
nt	12	10	8.68	8.06			14.4	15.3	
)	146	10	8.66	7.98			16.2		
nt	17	10	8.66	8.12			12		
	1	10	8.66	8.09			12.9	12.8	
	230	10	8.67	8.08			13.5		
	13	20	8.59	7.60			12.75		
t	15	20	8.61	7.75			10.8	11.45	
)	19	20	8.61	7.75			10.8		
nt	10	20	8.61	7.79			10.2		
	20	20	8.58	7.76			10.2	10.55	
)	14	20	8.57	7.68			11.25		
	9	10	8.66	7.34			35.4		
t	5	10	8.66	7.36			34.8	35.9	
	12	10	8.64	6.40			37.5		

TP

8/9/2004

BOD DATA SHEET

e			Analyzer						
ole	Dilution B 10.	Vol. of Sample (ml)	Initial D.O. (mg/l)	Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
nt	22	10	8.67	7.50			30.9		
	216	10	8.67	7.55			29.4	31.7	
)	6	10	8.63	7.33			34.8		
mt	2301	20	8.51	6.56			27.2		
	24	20	8.53	6.42			29.6	29.3	
P)	7	20	8.49	6.27			31.2		
nt	18	20	8.53	6.69			25.5		
	11	20	8.53	6.55			27.6	27.2	
)	101	20	8.52	6.48			28.5		

4
TP

10/9/04

BOD DATA SHEET

ple	~~Dilution~~ 10	Vol. of Sample (ml)	Analyzer: Initial D.O. (mg/l)	Analyzer: Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
	1	-	8.6	8.45		0.15			
-	3	-	8.6	8.49		0.11			
	6	-	8.6	8.32		0.28			
	12	10	8.5	8.07			11.4		
ent	153	10	8.51	8.06			10.2	11.2	
	164	10	8.49	~~8~~7.98			12		
	16	10	8.6	7.92			17.1		
nt	15	10	8.58	8.02			13.5	14.1	
	200	10	8.56	8.00			11.7		
	7	20	8.56	7.5			14.25		
nt	12	20	8.50	7.62			11.55	12.4	
	44	20	8.49	7.63			11.25		
	8	20	8.55	7.6			12.6		
nt	9	20	8.56	7.59			12.9	13.7	
	90	20	8.55	7.4			15.6		
	88	10	8.59	7.33			34.5		
nt	40	10	8.55	7.37			32.1	33.1	
	32	10	8.56	7.36			32.7		

STP 10/9/04.

BOD DATA SHEET

e			Analyzer						
le	~~Dilution~~ IP	Vol. of Sample (ml)	Initial D.O. (mg/l)	Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
	20	10	8.46	7.01			40.2		
ent	22	10	8.56	7.32			33.9	34.9	
	23	10	8.49	7.76			30.6		
	1101	20	8.55	7.11			19.95		
nt	1100	20	8.45	7.11			18.45	18.7	
	77	20	8.44	7.15			17.7		
	26	20	8.48	6.97			20.55		
nt	27	20	8.32	6.9			19.65	22.4	
	28	20	8.44	6.53			27		

ilot Plant 10/9/04

BOD DATA SHEET

e			Analyzer						
le	~~Dilution~~ ID	Vol. of Sample (ml)	Initial D.O. (mg/l)	Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
	55	10	8.59	8.31			5.1		
nt	500	10	8.58	8.32			4.5	4.2	
	510	10	8.57	8.36			3		
	652	10	8.55	8			13.2		
nt	653	10	8.56	8.11			10.2	11.2	
	657	10	8.57	8.12			10.2		
	.71	20	8.49	8.07			5.55		
nt	72	20	8.47	8.06			4.5	4.9	
	7	20	8.47	8.06			4.5		
	1655	20	8.44	8.06			4.05		
nt	1654	20	8.47	8.05			4.65	4.15	
	1653	20	8.47	8.11			3.75		
	98	20	8.49	6.53			27.75		
t	97	20	8.48	6.96			21.15	23.1	
	96	20	8.44	6.98			20.25		
	300	20	8.44	6.5			27.45		
t	301	20	8.45	6.53			27.15	27.45	
	302	20	8.49	6.53			27.75		

07 Plant 10/9/04

BOD DATA SHEET

e		Analyzer						
le	~~Dilution~~ ID	Vol. of Sample (ml)	Initial D.O. (mg/l)	Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
	61	10	8.56	7.93			15.6		
...ut	62	10	8.55	7.95			14.7	15.3	
	63	10	8.56	7.93			15.6		
	322	10	8.56	7.73			24.6		
...ut	321	10	8.57	7.7			22.8	22.1	
	326	10	8.55	7.71			21.9		

Test 5   13/10/04

after addition of 20% chem

BOD DATA SHEET

e	Dilution B. 10	Vol. of Sample (ml)	Analyzer Initial D.O. (mg/l)	Analyzer Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
	9		8.71	8.36		0.35			
	22		8.70	8.50		0.2			
	13 *		8.70	8.56		0.14			
	8	20	8.45	6.93			20.7		
t	6	20	8.45	6.77			23.1	20.55	
	12201	20	8.48	7.15			17.85		
	1167	20	8.43	7.02			19.05		
t	73	20	8.43	7.18			16.65	17.85	
	211	20	8.44	7.11			17.85		
	92	10	8.56	7.71			21.3		
t	230	10	8.53	7.55			25.2	23.9	
	918	10	8.54	7.56			25.2		
	1111	10	8.55	7.57			25.2		
t	171	10	8.58	7.76			20.4	22.6	
	222	10	8.56	7.68			22.2		
	1701	10	8.50	5.39			89.1		
t	1130	10	8.53	5.85			76.2	79.2	
	1220	10	8.58	6.03			72.3		

rp

13/10/04

BOD DATA SHEET									
			Analyzer						
le	~~Dilution~~ B 16	Vol. of Sample (ml)	Initial D.O. (mg/l)	Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
	2001	10	8.51	5.86			75.3		
t	3555	10	8.51	5.78			77.7	76.3	
	3111	10	8.52	5.85			75.9		
	1216	20	8.31	2.51			84.9		
it	1101	20	8.31	1.95			93.3	90.3	
	611	20	8.33	2.01			92.7		
	231	20	8.33	2.41			86.7		
it	232	20	8.36	1.40			102.3	91.6	
	1507	20	8.36	2.51			85.65		

Plant. after add 20% of Chem waste. 13/10/04

BOD DATA SHEET

e	~~Dilution~~ B 10.	Vol. of Sample (ml)	Analyzer Initial D.O. (mg/l)	Analyzer Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
	547	10	8.67	8.12			12.3		
t	704	10	8.68	8.08			13.8	12.7	
	548	10	8.68	8.14			12		
	118	10	8.69	8.16			11.7		
t	719	10	8.69	8.15			11.7	11.4	
	128	10	8.69	8.19			10.8		
	101	20	8.60	7.85			9.15		
t	15	20	8.62	7.85			9.45	9.6	
	14	20	8.63	7.81			10.2		
	8	20	8.61	7.87			9		
t	721	20	8.68	7.83			10.65	9.6	
	141	20	8.63	7.88			9.15		
	817	10	8.65	7.98			15.9		
-	824	10	8.65	7.93			17.4	16.6	
	851	10	8.67	7.98			16.5		
	777	10	8.66	7.96			16.8		
	100	10	8.66	8.01			15.3	15.8	
	718	10	8.65	8.00			15.3		

BOD DATA SHEET

e	Dilution	Vol. of Sample (ml)	Analyzer Initial D.O. (mg/l)	Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
	165	20	8.46	7.34			14.7		
t	167	20	8.48	7.39			14.25	~~16.6~~ 14.1	
	152	20	8.45	7.42			13.35		
	912	20	8.49	7.49			12.9		
it	1,501	20	8.49	7.44			13.65	13.85	
	200	20	8.46	7.32			15		

Test 6

21/10/04

BOD DATA SHEET

			Analyzer						
e	~~Dilution~~ B. ID.	Vol. of Sample (ml)	Initial D.O. (mg/l)	Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
	*9	-	8.89	8.85		0.04			
	160	-	8.89	8.84		0.05			
	548	-	8.89	8.82		0.07			
	290	10	8.83	8.33			6.9		
A	201	10	8.84	8.37			6.45	6.45	
	168	10	8.82	8.38			6		
	400	10	8.84	8.27			7.95		
l	220	10	8.83	8.31			7.2	7.45	
	23	10	8.82	8.30			7.2		
	2001	20	8.67	7.81			24.6		
A	912	20	8.69	7.76			26.7	29	
	18	20	8.70	7.47			35.7		
	719	20	8.64	7.56			31.2		
A	1701	20	8.65	7.76			25.5	27.7	
	704	20	8.65	7.73			26.4		

STP

21/10/04

BOD DATA SHEET									
			Analyzer						
e	~~Dilution~~ B 1.0	Vol. of Sample (ml)	Initial D.O. (mg/l)	Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
	164	10	8.81	6.72			61.5		
t	221	10	8.83	6.68			63.3	61.9	
	141	10	8.81	6.74			60.9		
	165	10	8.78	6.51			66.9		
d	2301	10	8.78	6.73			60.3	62.5	
	821	10	8.79	6.74			60.3		
	113	20	8.65	4.19			66.3		
t	7	20	8.65	4.25			65.4	66.9	
	1141	20	8.64	4.00			69		
	167	20	8.63	4.33			63.9		
t	1101	20	8.62	4.13			66.75	64.8	
	13	20	8.63	4.34			63.75		

Pilot Plant Test 6 21/10/04.

BOD DATA SHEET

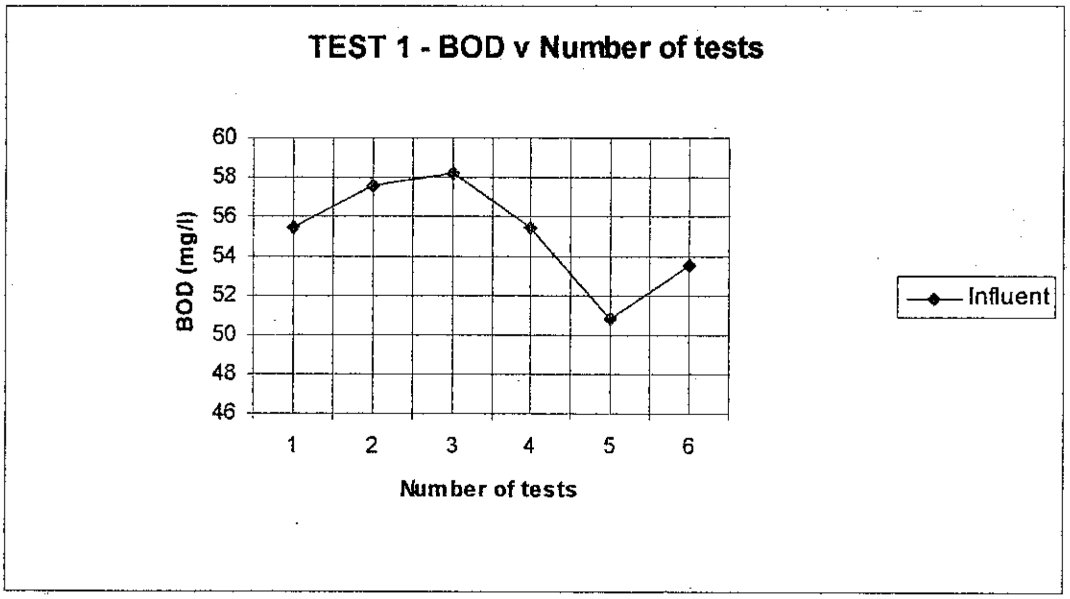
		Analyzer						
~~Dilution~~ B. I.N	Vol. of Sample (ml)	Initial D.O. (mg/l)	Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
110	10	8.8	8.7			1.8		
111	10	8.79	8.64			3.3	1.9	
1112	10	8.75	8.69			0.6		
56	10	8.56	8.48			1.2		
55	10	8.54	8.42			2.4	1.9	
54	10	8.55	8.44			2.1		
57	20	8.4	8.29			1.05		
58	20	8.49	8.36			1.35	1.45	
59	20	8.45	8.28			1.95		
23	20	8.44	8.25			2.25		
24	20	8.46	8.34			1.2	1.5	
26	20	8.44	8.33			1.05		
27	10	8.3	7.98			8.4		
28	10	8.36	7.95			11.1	8.9	
29	10	8.39	8.11			7.2		
89	10	8.34	7.98			9.6		
88	10	8.35	7.97			10.2	9.7	
890	10	8.36	8.01			9.3		

BOD DATA SHEET

e	Dilution	Vol. of Sample (ml)	Analyzer Initial D.O. (mg/l)	Final D.O. (mg/l)	Seed (ml)	Seed/ Blank Correction	BOD (mg/l)	Avg. BOD (mg/l)	Comments
	20	20	8.44	7.69			10.65		
+	200	20	8.43	7.67			10.8	10.65	
	201	20	8.43	7.69			10.5		
+	911	20	8.44	7.68			10.8		
	9112	20	8.43	7.70			10.35	10.5	
	9	20	8.44	7.71			10.35		

Test 1 (Aeration influent on 18/8/2004, time ; 11.00 am)

Sample	Bottle ID	Vol of sample	Initial DO	Final DO	Blank Correlation	BOD	Avg BOD
Blank	150	-	8.78	8.58	0.2		
	22	-	8.78	8.57	0.21		
	16	-	8.78	8.66	0.12		
Influent Aeration	146	10	8.65	6.68		55.5	57.1
	20	10	8.63	6.59		57.6	
	18	10	8.68	6.62		58.2	
	19	20	8.46	4.64		55.5	53.3
	6	20	8.45	4.94		50.85	
	23	20	8.45	4.76		53.55	



Test 2 (Held on 26/8/04, time ; 11.00 am)

STP

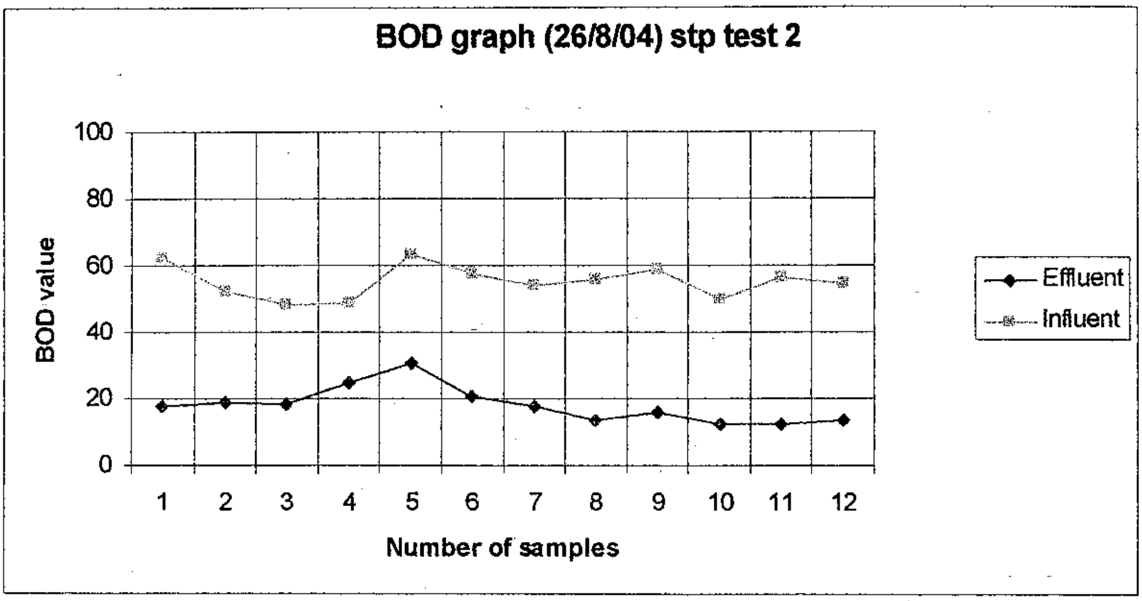
Sample	Bottle ID	Vol of sample	Initial DO	Final DO	Blank Correlation	BOD	Avg BOD
Blank	8	-	8.74	8.05	0.69		
	9	-	8.74	8.34	0.4		
	10	-	8.74	8.35	0.39		
Effluent	20	10	8.64	7.67		17.4	18.1
	16	10	8.63	7.62		18.6	
	7	10	8.65	7.65		18.3	
	10	10	8.64	7.43		24.6	25.2
	23	10	8.63	7.22		30.6	
	165	10	8.62	7.55		20.4	
	21	20	8.48	6.93		17.4	15.6
	11	20	8.48	7.17		13.8	
	5	20	8.51	7.08		15.6	
	12	20	8.51	7.29		12.45	12.8
	22	20	8.53	7.31		12.45	
	9	20	8.48	7.19		13.5	
Influent	1	10	8.5	6.04		62.1	54.1
	2	10	8.51	6.38		52.2	
	3	10	8.53	6.54		48	
	150	10	8.5	6.48		48.9	56.7
	17	10	8.51	6.01		63.3	
	18	10	8.5	6.18		57.9	
	153	20	8.25	4.25		54.15	56.2
	6	20	8.28	4.17		55.8	
	24	20	8.28	3.98		58.65	
	15	20	8.32	4.58		50.25	53.7
	167	20	8.28	4.13		56.4	
	13	20	8.3	4.28		54.45	

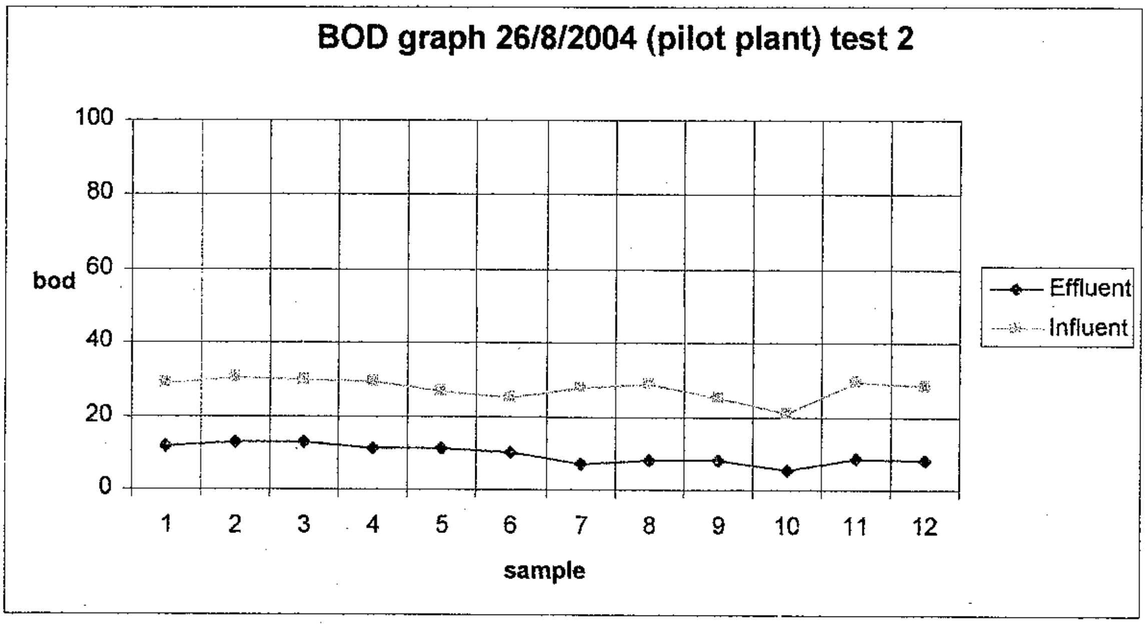
BOD for influent = 57
BOD for effluent = 18

Pilot plant

Sample	Bottle ID	Vol of sample	Initial DO	Final DO	Blank Correlation	BOD	Avg BOD
Blank	8	-	8.74	8.05	0.69		
	9	-	8.74	8.34	0.4		
	10	-	8.74	8.35	0.39		
Effluent	13	10	8.69	7.9		12	12.6
	15	10	8.64	7.82		12.9	
	77	10	8.67	7.85		12.9	
	12	10	8.7	7.94		11.1	10.8
	26	10	8.71	7.95		11.1	
	33	10	8.72	7.99		10.2	
	35	20	8.5	7.66		6.75	7.7
	36	20	8.55	7.62		8.1	
	37	20	8.56	7.62		8.25	
	1101	20	8.54	7.78		5.55	7.45
	1105	20	8.56	7.59		8.7	
	1109	20	8.55	7.62		8.1	
Influent	97	10	8.4	7.04		29.1	29.7
	99	10	8.46	7.06		30.3	
	98	10	8.44	7.06		29.7	
	1000	10	8.56	7.19		29.4	27.2
	1050	10	8.51	7.22		27	
	1090	10	8.49	7.26		25.2	
	151	20	8.3	6.06		27.75	27.3
	153	20	8.36	6.05		28.8	
	159	20	8.4	6.32		25.35	
	225	20	8.15	6.36		21	26.25
	226	20	8.41	6.06		29.4	
	227	20	8.39	6.11		28.35	

BOD for influent =
27
BOD for effluent = 8


BOD graph (26/8/04) stp test 2
BOD value
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
11
12
Number of samples
Effluent
Influent


BOD graph 26/8/2004 (pilot plant) test 2
bod
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
11
12
sample
Effluent
Influent

Test 3 (Held on 8/9/04, time ; 11.00 am)

STP

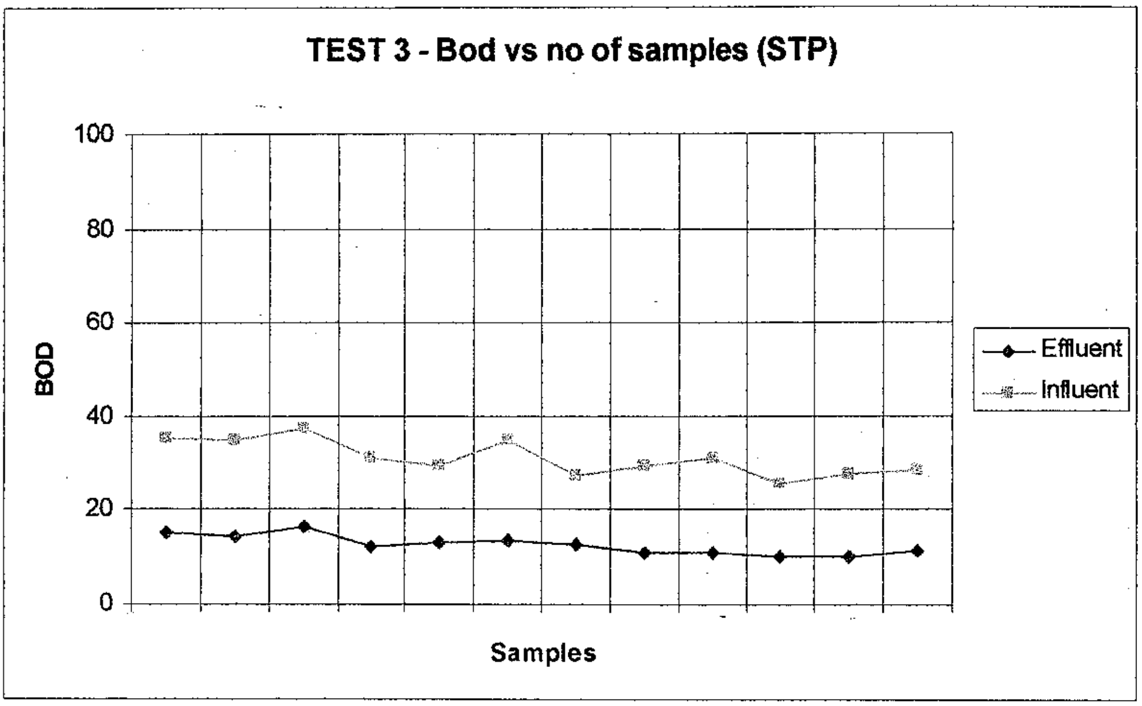
Sample	Bottle ID	Vol of sample	Initial DO	Final DO	Blank Correlation	BOD	Avg BOD
Blank	5	-	8.7	8.36	0.4		
	8	-	8.7	8.56	0.14		
	150	-	8.7	8.39	0.31		
Effluent	153	10	8.68	8.03		15.3	15.3
	12	10	8.68	8.06		14.4	
	146	10	8.66	7.98		16.2	
	17	10	8.66	8.12		12	12.8
	1	10	8.66	8.09		12.9	
	230	10	8.67	8.08		13.5	
	13	20	8.59	7.6		12.75	11.45
	15	20	8.61	7.75		10.8	
	19	20	8.61	7.75		10.8	
	10	20	8.61	7.79		10.2	10.55
	20	20	8.58	7.76		10.2	
	14	20	8.57	7.68		11.25	
Influent	9	10	8.66	7.34		35.4	35.9
	5	10	8.66	7.36		34.8	
	12	10	8.64	7.25		37.5	
	22	10	8.67	7.5		30.9	31.7
	216	10	8.67	7.55		29.4	
	6	10	8.63	7.33		34.8	
	2301	20	8.51	6.56		27.15	29.3
	24	20	8.53	6.42		29.55	
	7	20	8.49	6.27		31.2	
	18	20	8.53	6.69		25.5	27.2
	11	20	8.53	6.55		27.6	
	101	20	8.52	6.48		28.5	

BOD for influent = 30
BOD for effluent = 12

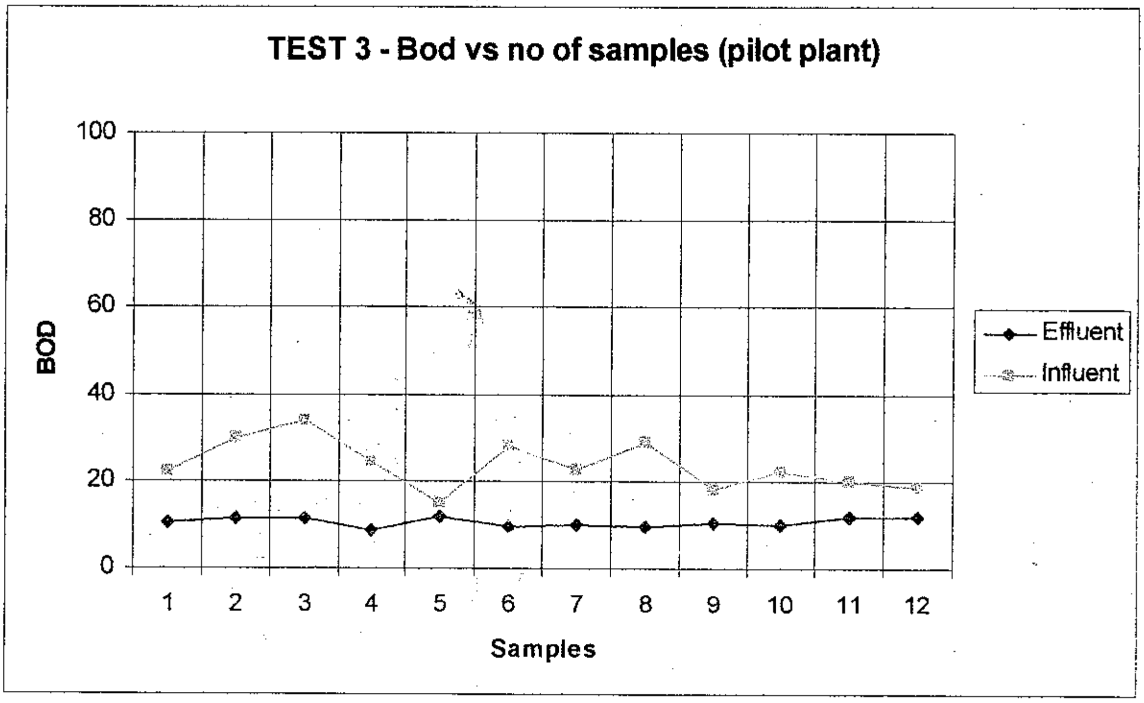
Pilot Plant

Sample	Bottle ID	Vol of sample	Initial DO	Final DO	Blank Correlation	BOD	Avg BOD
Blank	5	-	8.7	8.36	0.4		
	8	-	8.7	8.56	0.14		
	150	-	8.7	8.39	0.31		
Effluent	111	10	8.59	8.11		10.2	11
	60	10	8.6	8.08		11.4	
	235	10	8.62	8.1		11.4	
	1701	10	8.56	8.13		8.7	9.9
	237	10	8.58	8.05		11.7	
	152	10	8.58	8.13		9.3	
	200	20	8.54	7.75		9.75	9.8
	241	20	8.54	7.78		9.3	
	167	20	8.54	7.71		10.35	
	1411	20	8.54	7.74		9.9	11.2
	1167	20	8.56	7.63		11.85	
	271	20	8.56	7.63		11.85	
Influent	3	20	8.66	7.03		22.35	28.7
	1101	20	8.67	6.53		30	
	721	20	8.66	6.27		33.75	
	618	20	8.57	6.79		24.6	22.6
	821	20	8.56	7.41		15.15	
	11501	20	8.59	6.58		28.05	
	165	10	8.6	7.7		22.8	23.3
	290	10	8.63	7.53		28.8	
	400	10	8.6	7.85		18.3	
	320	10	8.62	7.74		22.2	20.2
	316	10	8.58	7.78		19.8	
	47	10	8.58	7.82		18.6	

BOD for influent = 29
BOD for effluent = 11



TEST 3 - Bod vs no of samples (STP)
100
80
60
40
20
0
BOD
Samples
Effluent
Influent



TEST 3 - Bod vs no of samples (pilot plant)
100
80
60
40
20
0
BOD
1
2
3
4
5
6
7
8
9
10
11
12
Samples
Effluent
Influent

Test 4 (Held on 10/9/04, time ; 11.00 am)

STP

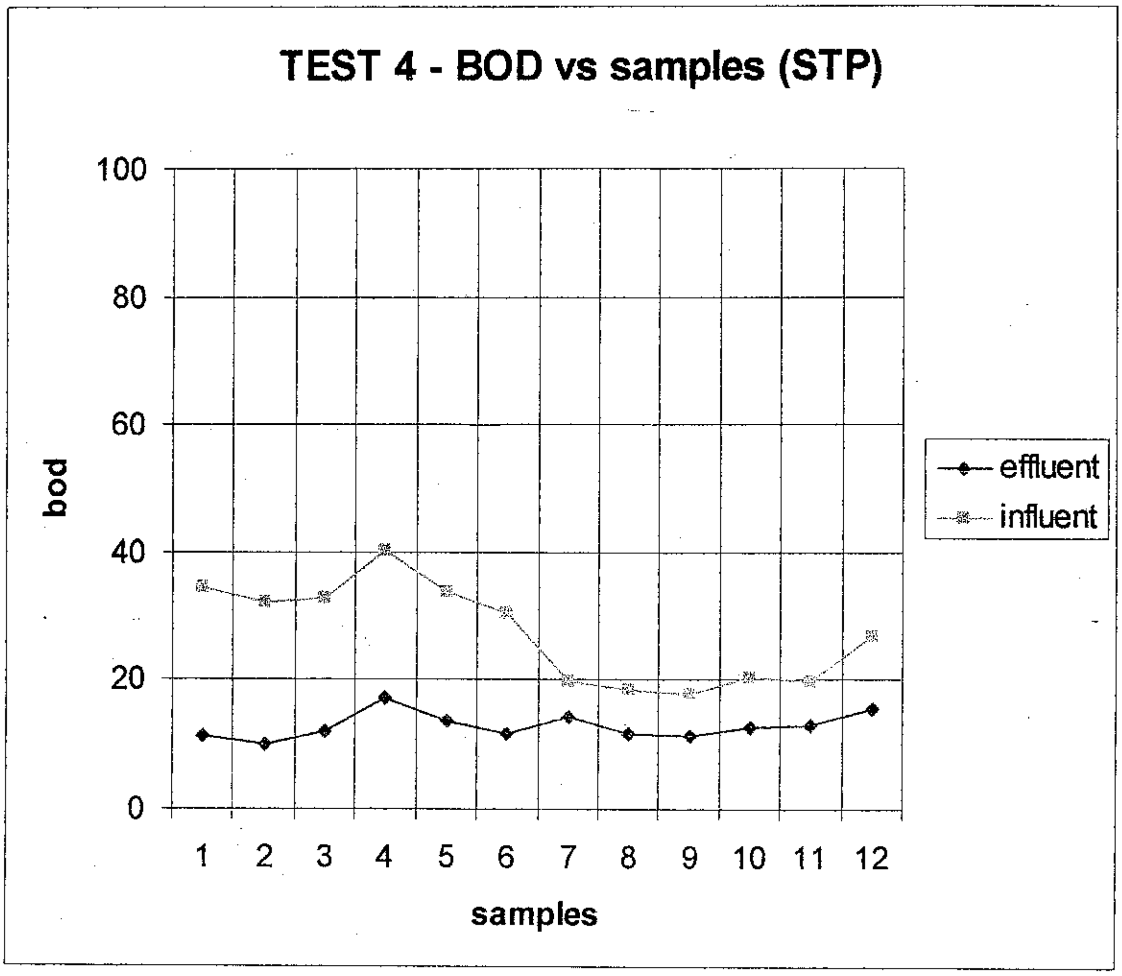
Sample	Bottle ID	Vol of sample	Initial DO	Final DO	Blank Correlation	BOD	Avg BOD
Blank	1	-	8.6	8.45	0.15		
	3	-	8.6	8.49	0.11		
	6	-	8.6	8.32	0.28		
Effluent	12	10	8.5	8.01		11.4	11.2
	153	10	8.51	8.06		10.2	
	164	10	8.49	7.98		12	
	16	10	8.6	7.92		17.1	14.1
	15	10	8.58	8.02		13.5	
	200	10	8.56	8.06		11.7	
	7	20	8.56	7.5		14.25	12.35
	12	20	8.5	7.62		11.55	
	44	20	8.49	7.63		11.25	
	8	20	8.55	7.6		12.6	13.7
	9	20	8.56	7.59		12.9	
	90	20	8.55	7.4		15.6	
Influent	88	10	8.59	7.33		34.5	33.1
	40	10	8.55	7.37		32.1	
	32	10	8.56	7.36		32.7	
	20	10	8.46	7.01		40.2	34.9
	22	10	8.56	7.32		33.9	
	23	10	8.49	7.36		30.6	
	1101	20	8.55	7.11		19.95	18.7
	1100	20	8.45	7.11		18.45	
	77	20	8.44	7.15		17.7	
	26	20	8.45	6.97		20.55	22.4
	27	20	8.32	6.9		19.65	
	28	20	8.44	6.53		27	

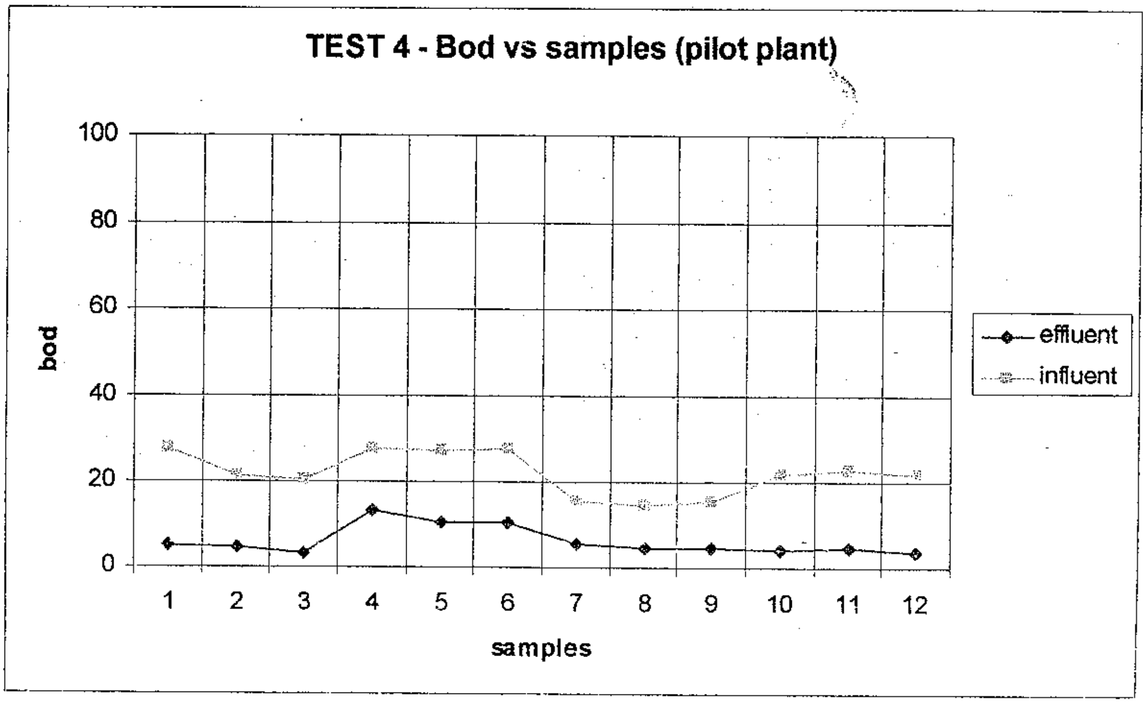
BOD for influent = 35
BOD for effluent = 14

Pilot Plant

Sample	Bottle ID	Vol of sample	Initial DO	Final DO	Blank Correlation	BOD	Avg BOD
Blank	1	-	8.6	8.45	0.15		
	3	-	8.6	8.49	0.11		
	6	-	8.6	8.32	0.28		
Effluent	55	10	8.59	8.31		5.1	4.2
	500	10	8.58	8.32		4.5	
	510	10	8.57	8.36		3	
	652	10	8.55	8		13.2	11.2
	653	10	8.56	8.11		10.2	
	651	10	8.57	8.12		10.2	
	71	20	8.49	8.01		5.55	4.85
	72	20	8.47	8.06		4.5	
	7	20	8.47	8.06		4.5	
	1655	20	8.44	8.06		4.05	4.15
	1654	20	8.47	8.05		4.65	
	1653	20	8.47	8.11		3.75	
Influent	98	20	8.49	6.53		27.75	23.05
	97	20	8.48	6.96		21.15	
	96	20	8.44	6.98		20.25	
	300	20	8.44	6.5		27.45	27.45
	301	20	8.45	6.53		27.15	
	302	20	8.49	6.53		27.75	
	61	10	8.56	7.93		15.6	15.3
	62	10	8.55	7.95		14.7	
	63	10	8.56	7.93		15.6	
	322	10	8.56	7.73		21.6	22.1
	321	10	8.57	7.7		22.8	
	326	10	8.55	7.71		21.9	

BOD for influent = 27
BOD for effluent = 5


TEST 4 - BOD vs samples (STP)
100
80
60
40
20
0
bod
1 2 3 4 5 6 7 8 9 10 11 12
samples
effluent
influent


TEST 4 - Bod vs samples (pilot plant)
100
80
60
40
20
0
bod
1 2 3 4 5 6 7 8 9 10 11 12
samples
effluent
influent

STP

Sample	Bottle ID	Vol of sample	Initial DO	Final DO	Blank Correlation	BOD	Avg BOD
Blank	9	-	8.71	8.36	0.35		
	22	-	8.7	8.5	0.2		
	13	-	8.7	8.56	0.14		
Effluent	8	20	8.45	6.93		20.7	20.55
	6	20	8.45	6.77		23.1	
	12201	20	8.48	7.15		17.85	
	1167	20	8.43	7.02		19.05	17.85
	73	20	8.43	7.18		16.65	
	211	20	8.44	7.11		17.85	
	92	10	8.56	7.71		21.3	23.9
	230	10	8.53	7.55		25.2	
	918	10	8.54	7.56		25.2	
	1111	10	8.55	7.57		25.2	22.6
	171	10	8.58	7.76		20.4	
	222	10	8.56	7.68		22.2	
Influent	1701	10	8.5	5.39		89.1	79.2
	1130	10	8.53	5.85		76.2	
	1220	10	8.58	6.03		72.3	
	2001	10	8.51	5.86		75.3	76.3
	3555	10	8.51	5.78		77.7	
	3111	10	8.52	5.85		75.9	
	1216	20	8.31	2.51		84.9	90.3
	1101	20	8.31	1.95		93.3	
	611	20	8.33	2.01		92.7	
	231	20	8.33	2.41		86.7	91.55
	232	20	8.36	1.4		102.3	
	1507	20	8.36	2.51		85.65	

Test 5 (Held on 13/10/04, time ; 11.00 am) - after recycling sludge adding 20% of chemical waste

STP

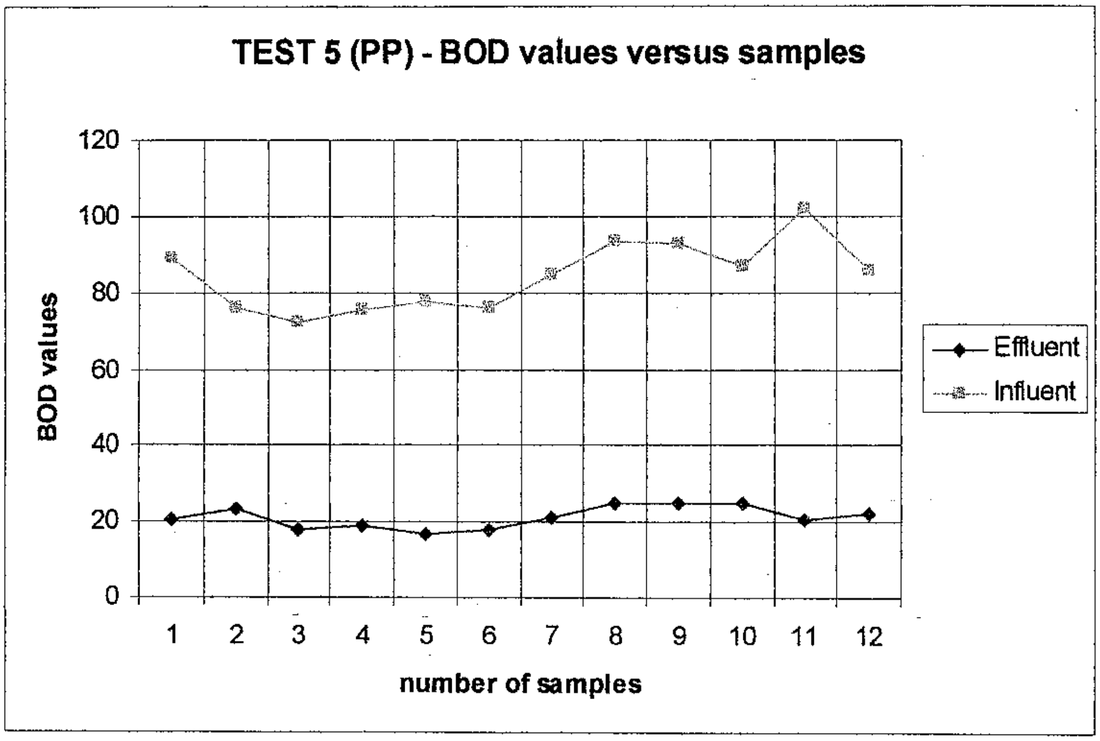
Sample	Bottle ID	Vol of sample	Initial DO	Final DO	Blank Correlation	BOD	Avg BOD
Blank	9	-	8.71	8.36	0.35		
	22	-	8.7	8.5	0.2		
	13	-	8.7	8.56	0.14		
Effluent	8	20	8.45	6.93		20.7	20.55
	6	20	8.45	6.77		23.1	
	12201	20	8.48	7.15		17.85	
	1167	20	8.43	7.02		19.05	17.85
	73	20	8.43	7.18		16.65	
	211	20	8.44	7.11		17.85	
	92	10	8.56	7.71		21.3	23.9
	230	10	8.53	7.55		25.2	
	918	10	8.54	7.56		25.2	
	1111	10	8.55	7.57		25.2	22.6
	171	10	8.58	7.76		20.4	
	222	10	8.56	7.68		22.2	
Influent	1701	10	8.5	5.39		89.1	79.2
	1130	10	8.53	5.85		76.2	
	1220	10	8.58	6.03		72.3	
	2001	10	8.51	5.86		75.3	76.3
	3555	10	8.51	5.78		77.7	
	3111	10	8.52	5.85		75.9	
	1216	20	8.31	2.51		84.9	90.3
	1101	20	8.31	1.95		93.3	
	611	20	8.33	2.01		92.7	
	231	20	8.33	2.41		86.7	91.55
	232	20	8.36	1.4		102.3	
	1507	20	8.36	2.51		85.65	

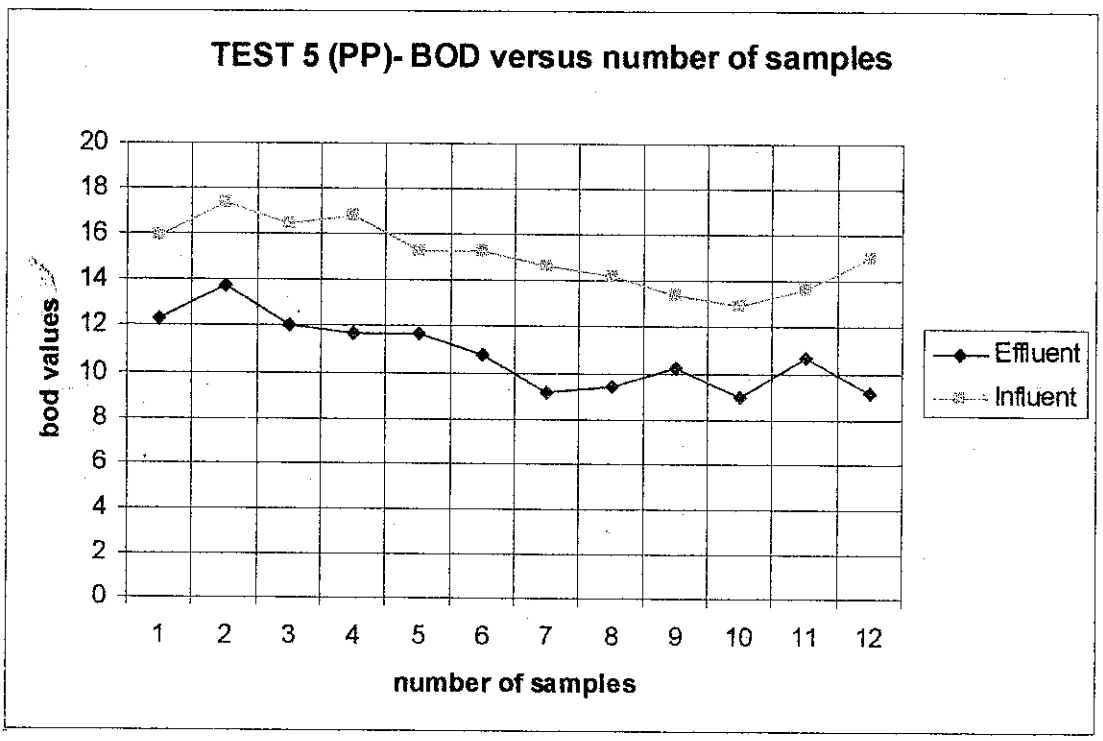
BOD for influent = 91
BOD for effluent = 22

Pilot Plant

Sample	Bottle ID	Vol of sample	Initial DO	Final DO	Blank Correlation	BOD	Avg BOD
Blank	9	-	8.71	8.36	0.35		
	22	-	8.7	8.5	0.2		
	13	-	8.7	8.56	0.14		
Effluent	547	10	8.67	8.12		12.3	12.7
	704	10	8.68	8.08		13.8	
	548	10	8.68	8.14		12	
	118	10	8.69	8.16		11.7	11.4
	719	10	8.68	8.15		11.7	
	128	10	8.69	8.19		10.8	
	101	20	8.6	7.85		9.15	9.6
	15	20	8.62	7.85		9.45	
	14	20	8.63	7.81		10.2	
	8	20	8.61	7.87		9	9.6
	721	20	8.68	7.83		10.65	
	141	20	8.63	7.88		9.15	
Influent	817	10	8.65	7.98		15.9	16.6
	824	10	8.65	7.93		17.4	
	851	10	8.67	7.98		16.5	
	777	10	8.66	7.96		16.8	15.8
	100	10	8.66	8.01		15.3	
	718	10	8.65	8		15.3	
	165	20	8.46	7.34		14.7	14.1
	167	20	8.48	7.39		14.25	
	152	20	8.45	7.42		13.35	
	912	20	8.49	7.49		12.9	13.85
	11501	20	8.49	7.44		13.65	
	200	20	8.46	7.32		15	

BOD for influent = 15
BOD for effluent = 10


TEST 5 (PP) - BOD values versus samples
120
100
80
60
40
20
0
BOD values
1
2
3
4
5
6
7
8
9
10
11
12
number of samples
Effluent
Influent


TEST 5 (PP)- BOD versus number of samples
20
18
16
14
12
10
8
6
4
2
0
bod values
1
2
3
4
5
6
7
8
9
10
11
12
number of samples
Effluent
Influent

Test 6 (Held on 21/10/04, time ; 11.00 am)

STP

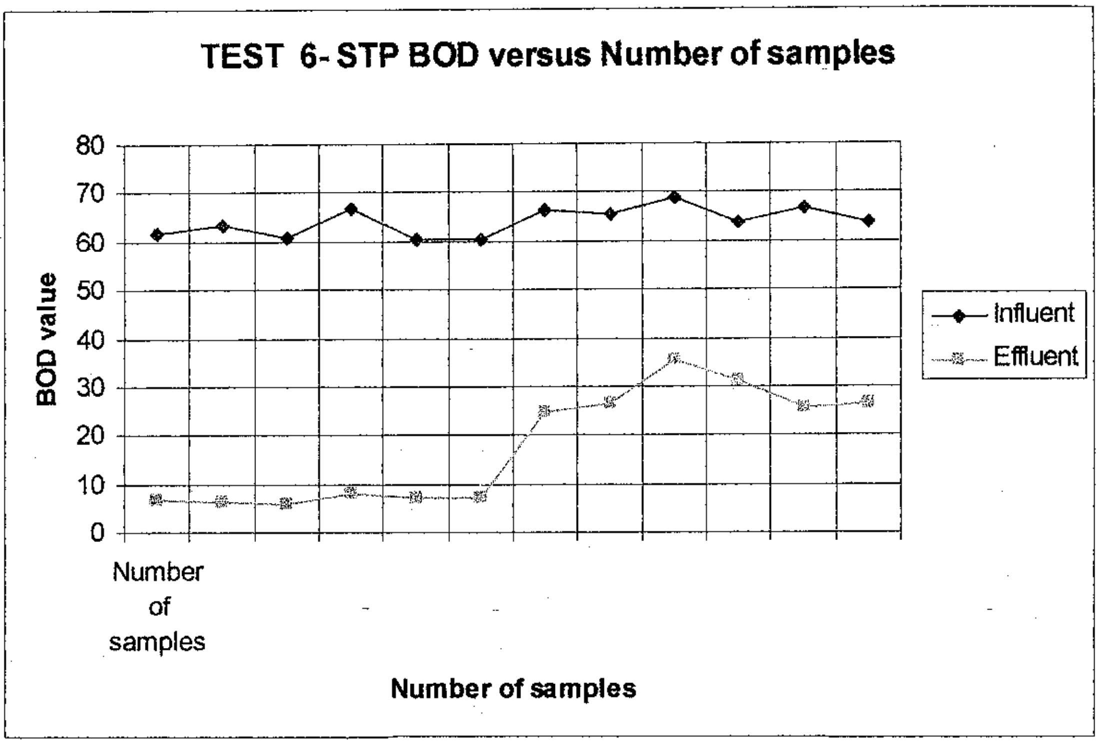
Sample	Bottle ID	Vol of sample	Initial DO	Final DO	Blank Correlation	BOD	Avg BOD
Blank	9	-	8.89	8.85	0.04		
	160	-	8.89	8.84	0.05		
	548	-	8.89	8.82	0.07		
Effluent	290	20	8.83	8.33		6.9	6.45
	201	20	8.84	8.37		6.45	
	168	20	8.82	8.38		6	
	400	20	8.84	8.27		7.95	7.45
	220	20	8.83	8.31		7.2	
	23	20	8.82	8.3		7.2	
	2001	10	8.67	7.81		24.6	29
	912	10	8.69	7.76		26.7	
	18	10	8.7	7.47		35.7	
	719	10	8.64	7.56		31.2	27.7
	1701	10	8.65	7.76		25.5	
	704	10	8.65	7.73		26.4	
Influent	164	10	8.81	6.72		61.5	61.9
	221	10	8.83	6.68		63.3	
	141	10	8.81	6.74		60.9	
	165	10	8.78	6.51		66.9	62.5
	2301	10	8.78	6.73		60.3	
	821	10	8.79	6.74		60.3	
	113	20	8.65	4.19		66.3	66.9
	7	20	8.65	4.25		65.4	
	1141	20	8.64	4		69	
	167	20	8.63	4.33		63.9	64.8
	1101	20	8.62	4.13		66.75	
	13	20	8.63	4.34		63.75	

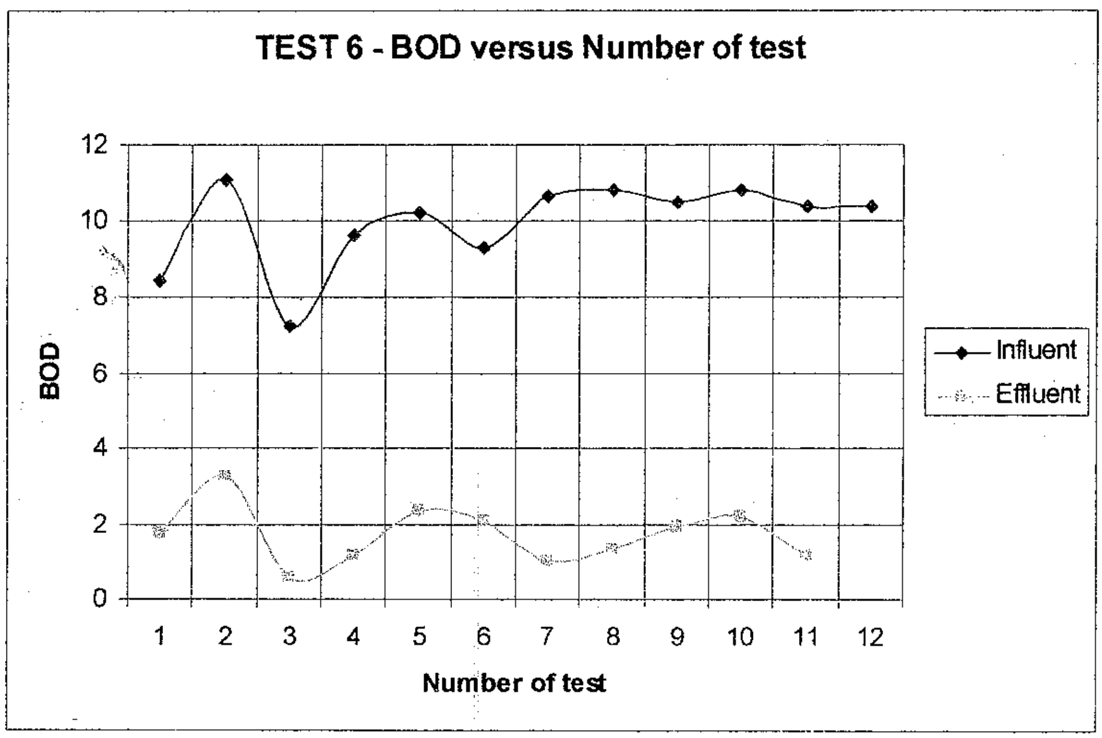
BOD for influent = 64
BOD for effluent = 18

Pilot Plant

Sample	Bottle ID	Vol of sample	Initial DO	Final DO	Blank Correlation	BOD	Avg BOD
Blank	9	-	8.89	8.85	0.04		
	160	-	8.89	8.84	0.05		
	548	-	8.89	8.82	0.07		
Effluent	110	10	8.8	8.7		1.8	
	111	10	8.79	8.64		3.3	1.9
	1112	10	8.75	8.69		0.6	
	56	10	8.56	8.48		1.2	
	55	10	8.54	8.42		2.4	1.9
	54	10	8.55	8.44		2.1	
	57	20	8.4	8.29		1.05	
	58	20	8.49	8.36		1.35	1.45
	59	20	8.45	8.28		1.95	
	23	20	8.44	8.25		2.25	
	24	20	8.46	8.34		1.2	1.5
	26	20	8.44	8.33		1.05	
Influent	27	10	8.3	7.98		8.4	
	28	10	8.36	7.95		11.1	8.9
	29	10	8.39	8.11		7.2	
	89	10	8.34	7.98		9.6	
	88	10	8.35	7.97		10.2	9.7
	890	10	8.36	8.01		9.3	
	20	20	8.44	7.69		10.65	
	200	20	8.43	7.67		10.8	10.65
	201	20	8.43	7.69		10.5	
	911	20	8.44	7.68		10.8	
	9112	20	8.43	7.7		10.35	10.5
	9	20	8.44	7.71		10.35	

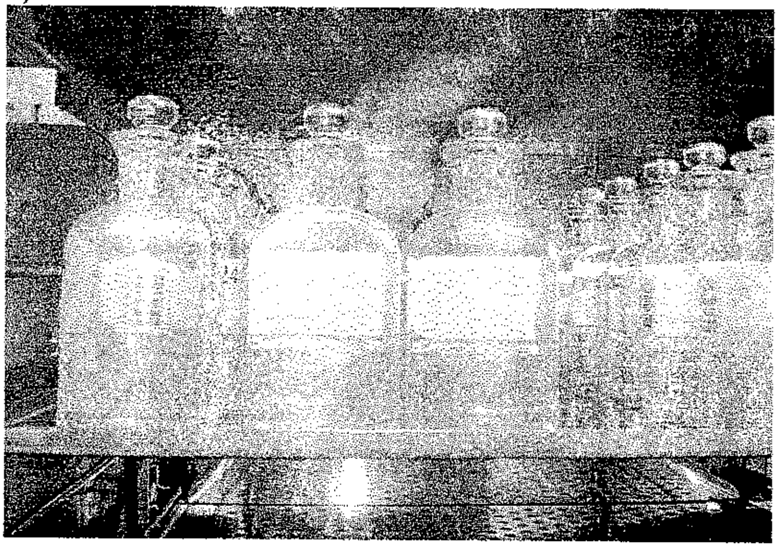
BOD for influent = 10
BOD for effluent = 2


TEST 6- STP BOD versus Number of samples
80
70
60
50
40
30
20
10
0
BOD value
Number of samples
Number of samples
Influent
Effluent

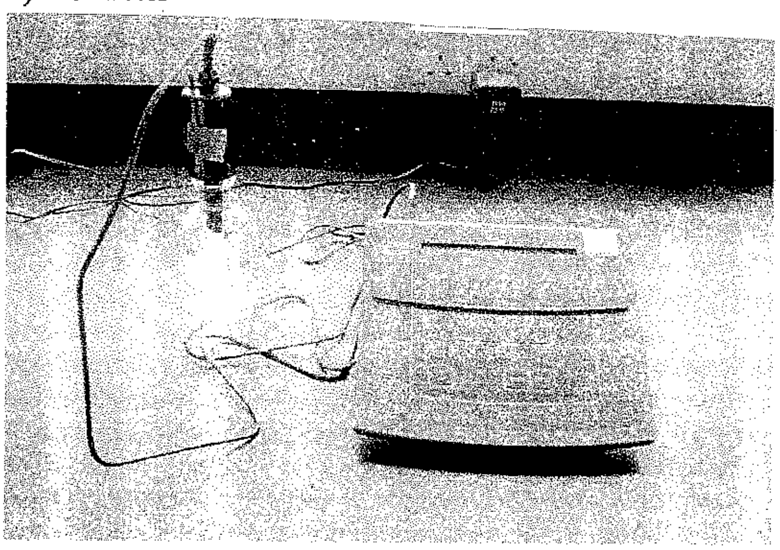

TEST 6 - BOD versus Number of test
12
10
8
6
4
2
0
BOD
1
2
3
4
5
6
7
8
9
10
11
12
Number of test
Influent
Effluent

APPENDIX 2: Pictures of laboratory equipments

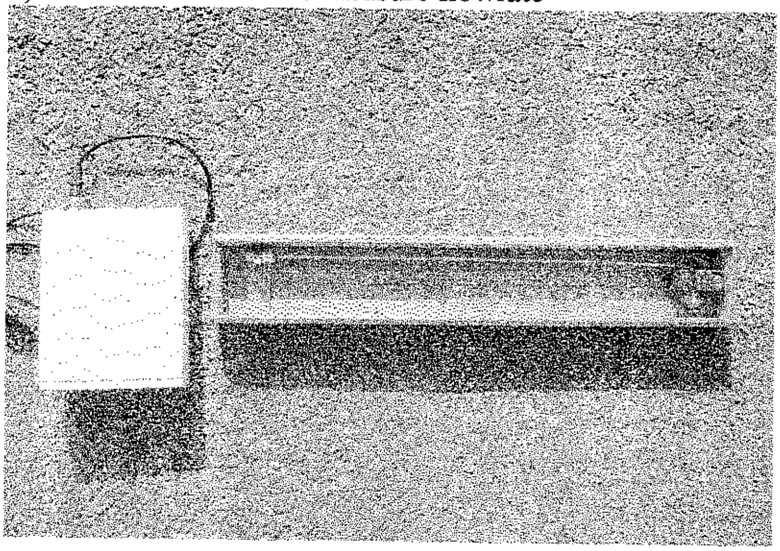
1) BOD bottles

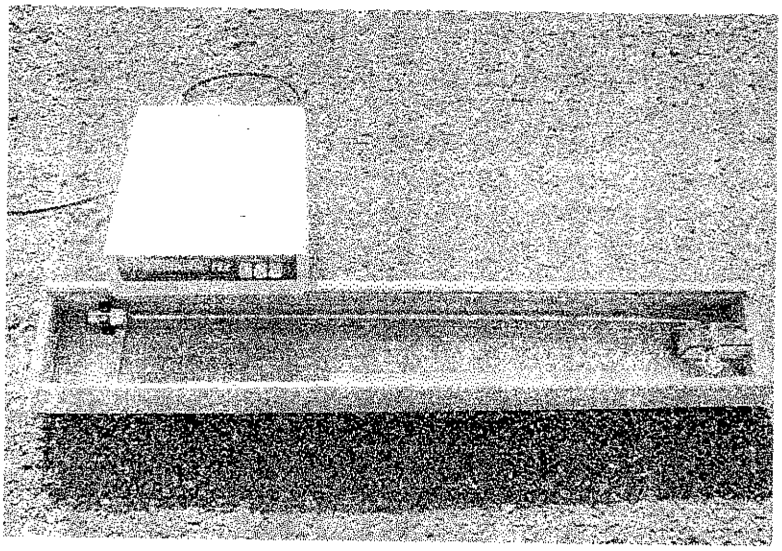


2) DO meter

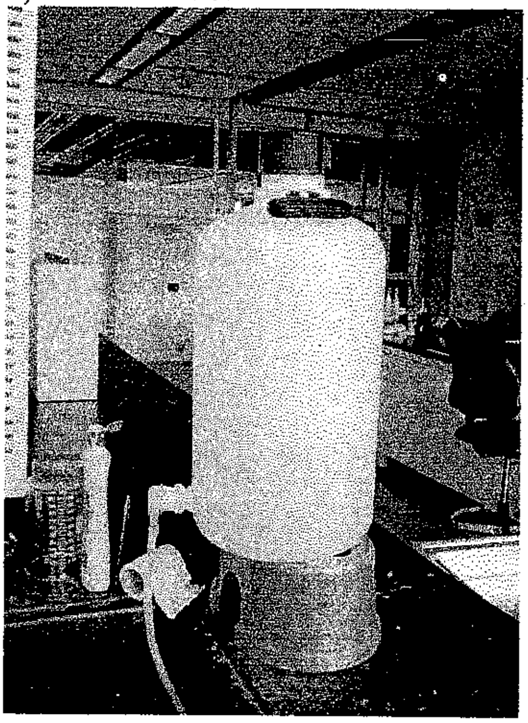


3) Manual flowmeter to measure flowrate



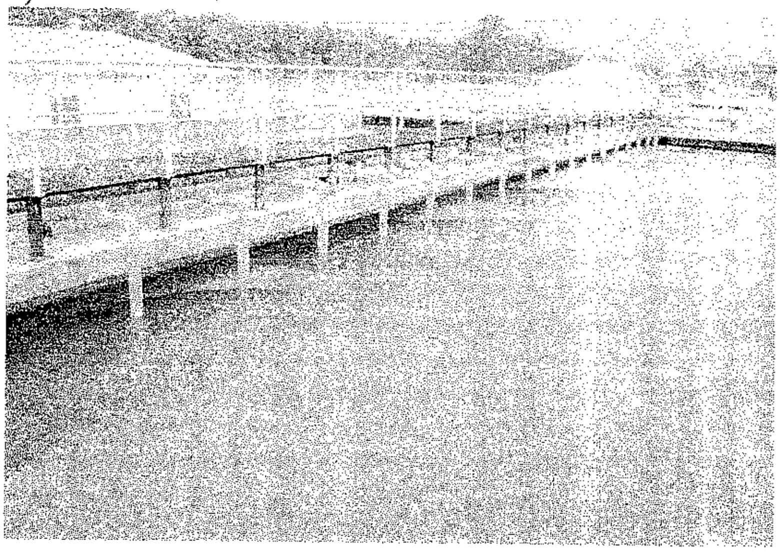


4) Distilled water

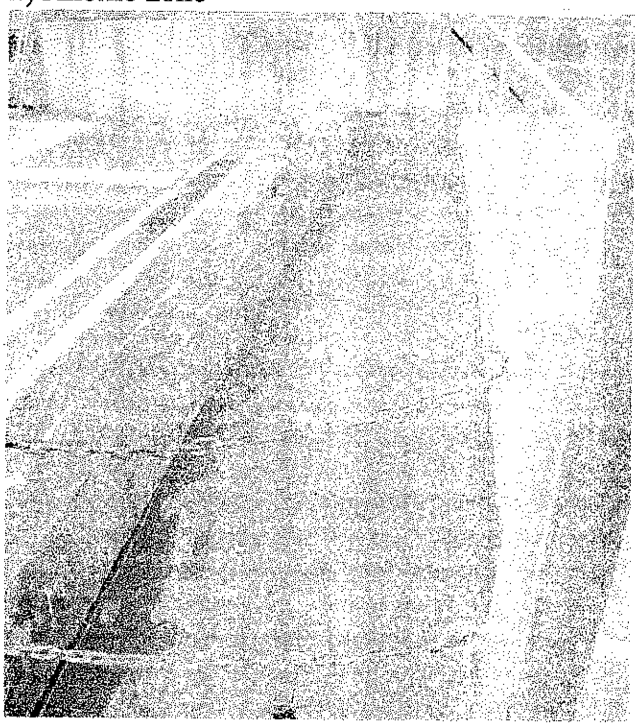


APPENDIX 3: Pictures of existing treatment plant

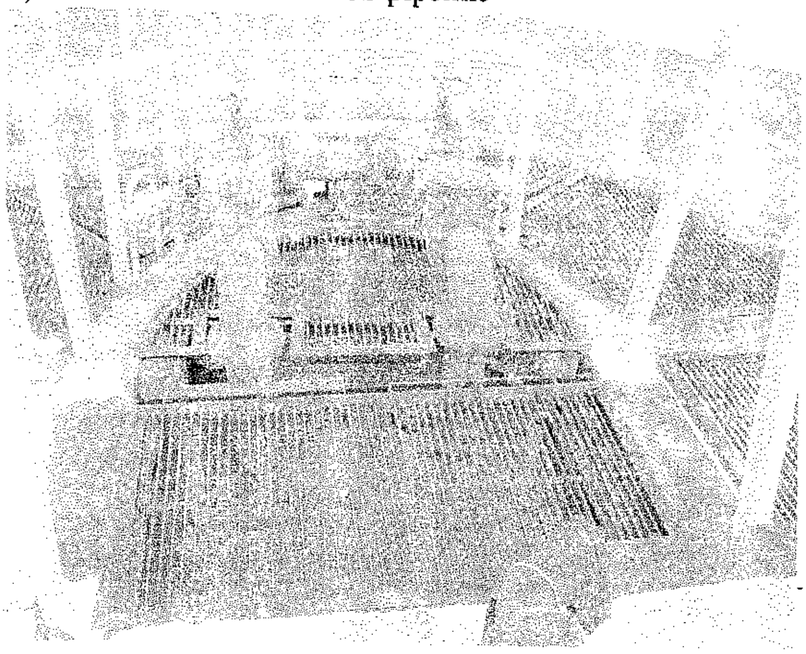
1) Aeration tank



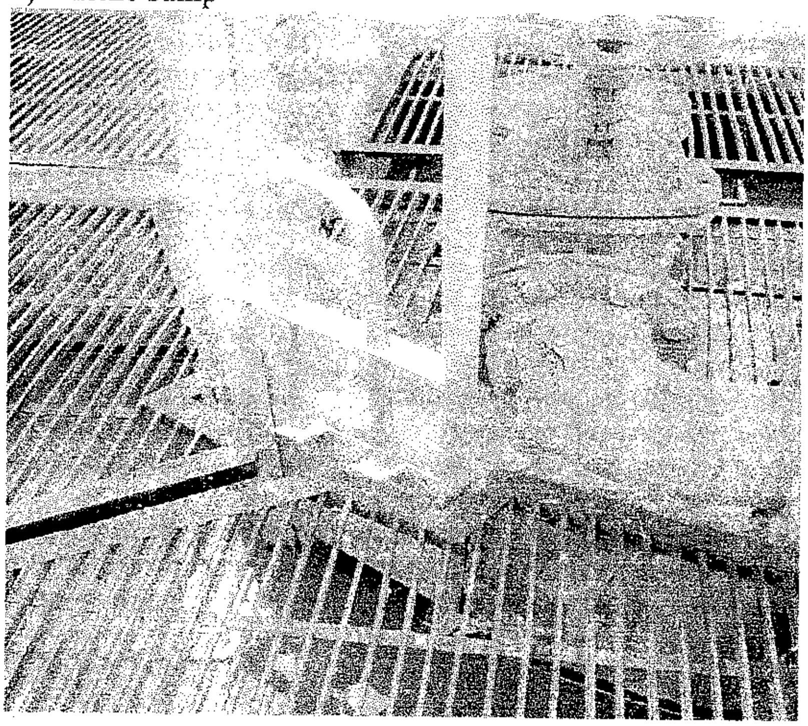
2) Anoxic zone



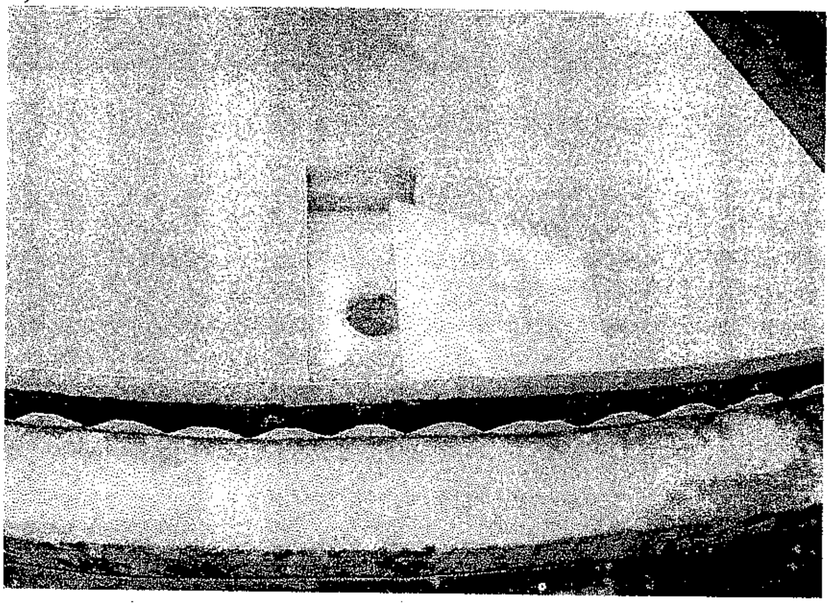
3) Malfunction return MLSS pipeline



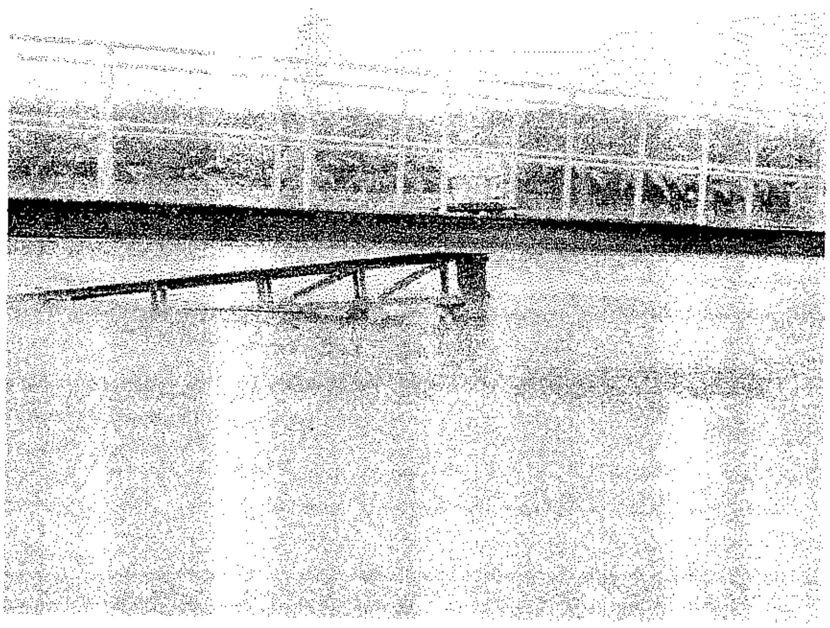
4) Anoxic sump



5) Scum box at clarifier



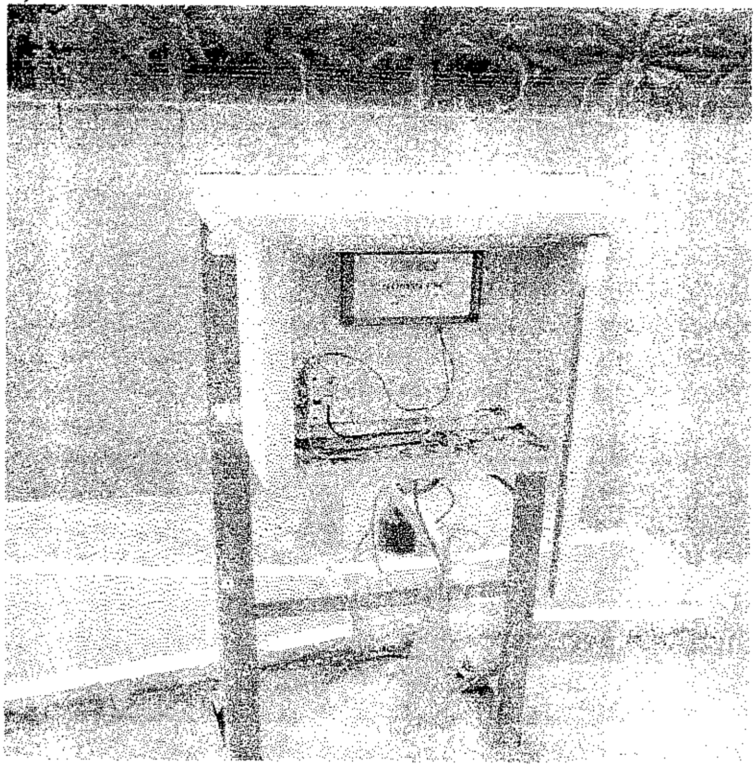
6) Malfunction scrapper at clarifier



7) Chlorination tank

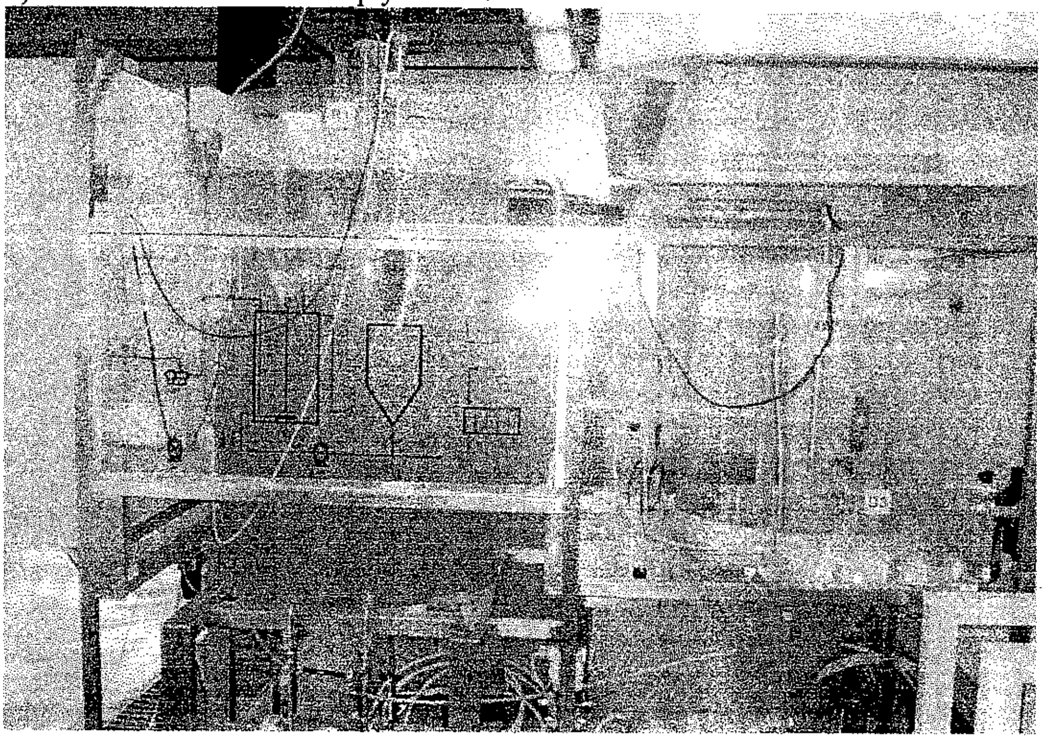
8) Malfunction turbine at clarifier

9) Malfunction flowmeter

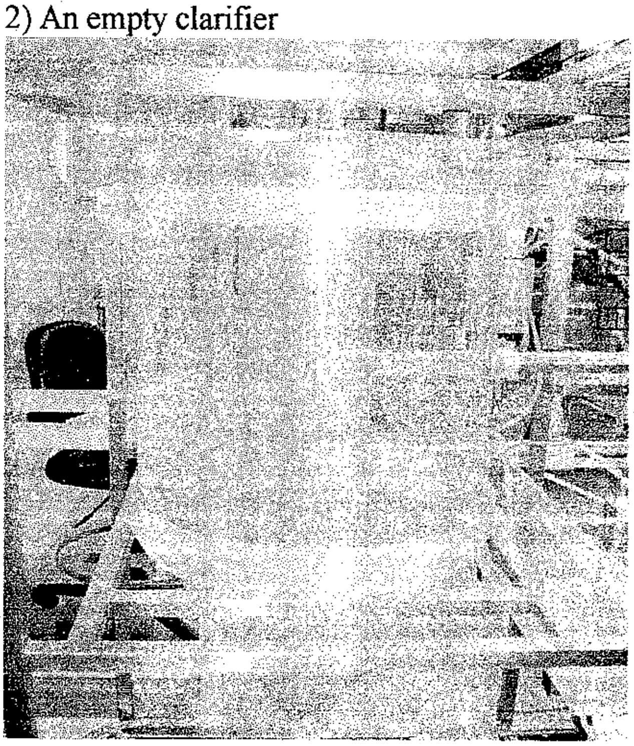


APPENDIX 4: Pilot plant pictures

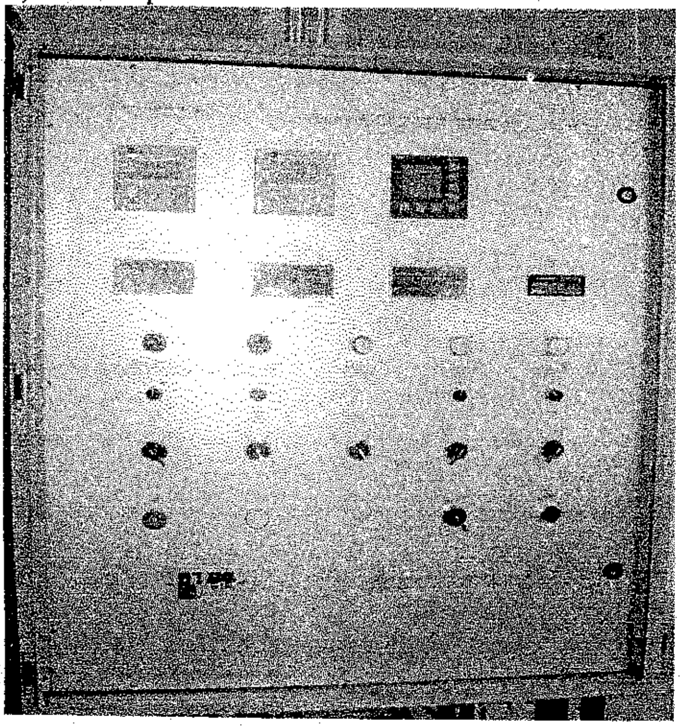
1) Aeration tank and an empty clarifier



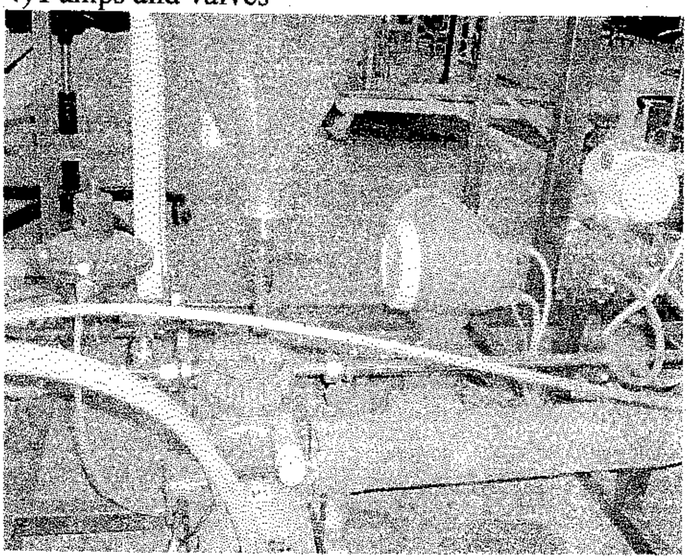
2) An empty clarifier



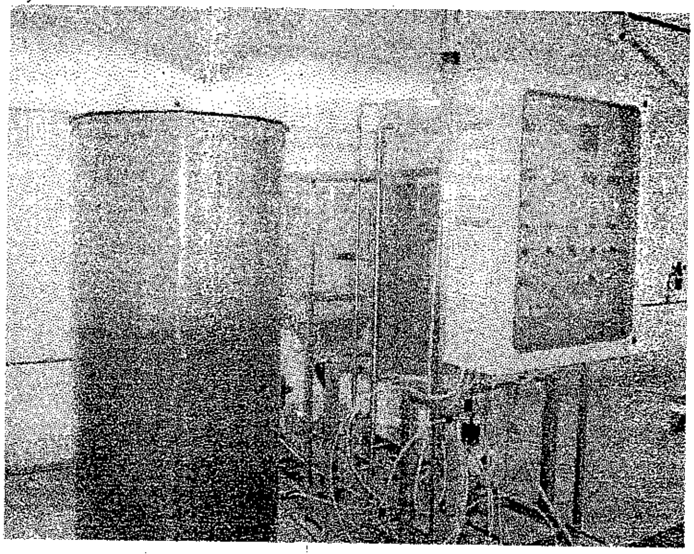
3) Control panel



4) Pumps and valves



7) Feeder tank



8) A full and working pilot plant