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Centralized Wastewater Treatment

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ABSTRACT An assessment was conducted of an integrated wastewater treatment plant (WWTP) in Malaysia. The WWTP has been designed to receive multiple effluents from central utility facilities (CUF) and other neighboring plants with varying wastewater characteristics. Commissioning of the plant was necessary as part of the quality assurance for the plant design specification. Operating units of the WWTP during commissioning are the intake collection, effluent monitoring, primary treatment operation, waste homogenizing and biological unit of processes. The assessment includes the monitoring of average flow rate, total suspended solids (TSS), oil & grease (O&G), pH, temperature, chemical oxygen demand (COD), dissolved oxygen (DO), and mixed liquor suspended solid (MLSS). The total COD loading in this plant is 1488 mg/l and at the final discharge point the COD reading was 63 mg/L. It shows that the WWTP has the COD removal rate of 96%. The total TSS loading is 331 mg/L and at the final discharge point the TSS reading was 27 mg/L. The DO reading was very satisfactory throughout the 2 months pre-commissioning period with an average reading between 3.0 to 4.0 mg/l and during the commissioning period of 8 days, an average DO reading of 4.2 mg/L was observed. The average MLSS reading was 1690 mg/L. The integrated WWTP is considered operating within the DOE Standard B discharge limit.

ABSTRAK Penilaian telah dilakukan atas loji bahan air sisa berpusat di Kerteh, Malaysia. Loji ini telah direkabentuk untuk menerima pelbagai effluen dari fasiliti utiliti berpusat dan loji berhampiran dengan ciri-ciri air sisa yang berbeza. Proses 'commissioning' loji adalah perlu sebagai jaminan kualiti untuk spesifikasi rekabentuk loji. Unit operasi loji semasa 'commissioning' adalah penerimaan influen, pemonitoran effluen, operasi bahan primer, campuran sisa, dan unit pemprosesan biologi. Penilaian yang dibuat termasuk pemonitoran purata kadar pengaliran jumlsh pepejal terapung (TSS), minyak dan gris, pH, suhu, COD, DO dan MLSS. Jumlah COD adalah 1488 mg/L dan COD effluen adalah 63 mg/L. Pengurangan COD adalah 96%. TSS asal adalah 331 mg/L dan nilai selepas olahan adalah 27 mg/L. Nilai purata DO adalah antara 3 hingga 4 mg/L dan semasa 'commissioning' nilai DO adalah 4.2 mg/L. Purata MLSS adalah 1690 mg/L. Loji ini didapati beroperasi dengan nilai 'standard' effluen seperti yang telah ditetapkan oleh JAS, Piawai B.

(centralized WWTP, multiple effluents, commissioning)

INTRODUCTION

Centralization of Wastewater Treatment Plant

Various researchers and institutions including the World Bank are considering decentralized wastewater management systems, as an alternative to the traditional system with the wastewater being treated in-situ. When mass-produced, the costs for manufacturing such package plants can presumably be kept at a relatively low level. The plants are delivered in a "user ready" state and produce an effluent, which is hygienically safe and can subsequently be utilized for toilet flushing, washing clothes, cleaning floors or watering lawns [1].

Building Wastewater Treatment Plant (WWTP) for each type of industry is quite a normal scene anywhere in the world. The WWTP is better controlled if the wastewater loading entering the plant is of one source only. But some industries have too little wastewater and do not have facilities in terms of space and finance to cater for building and controlling a WWTP. Therefore an integrated approach is more practical for these types of industries to co-operate and have only one treatment plant to cater to all types of waste. An industry can build their WWTP and include other wastes from various industries in their area. By making these industries pay for the waste load entering the plant, the owner indirectly sustains his own running cost of the WWTP.

Minimization of energy, chemicals and water consumption and a maximization reuse of treated wastewater and residues produced from the pollutants present in the wastewater, by implementing these concepts, wastewater like sewage and industrial effluents become an important resource for water, fertilizers and soil conditioners and also as an energy source [2]. In aerobic and anaerobic processes, the organic matter is decomposed to a soil-beneficial substrate, while the content of nutrients is maintained. Today these technologies play an important role in the development of sustainable waste management strategies. Recent development has focused on efforts to increase methane yields as well as degradation efficiencies of various kinds of organic wastes [3]. This paper discusses the approach used to build such a type of plant in Malaysia. Initial investigations of the various characteristics of the wastes contributed by other industries within the vicinity were carefully carried out. It is essential that the main wastewater contributors be identified before the plant is designed.

Wastewater Treatment Plant

An integrated WWTP was set up to handle combined effluents from Central Utilities Facilities (CUF) and BP PETRONAS Acetyl Sdn Bhd (BPPA) for a 400,000 tonnes acetic acid plant (AAP) and its neighbouring plants. The combined wastewater is from CUF and its customers. The wastewater consists of discharge from water filters, water demineralisation packages, boilers, cooling towers, waste from Acetic Acid Plant (BPPA), Vinyl Chloride Monomer Plant (VCM), and Ammonia Syngas Plant (ASGP). Wastewaters are also contributed from the CUF plant, which consists of plant run-off and storm water run-off. The existence of many types of industries in the vicinity of the main plant (CUF) contributes a variety of wastes to the environment. Thus, the client decided, from an economical point of view, to build one WWTP that integrates all the wastewaters that would cut down on the cost of operating and building many WWTP. The CUF is a biological secondary treatment system and it uses the activated sludge process to treat the combined waste. The main reason for the commissioning of the WWTP is to hand over the project to the client by the contractor.

Process Description

Design Specification

The Centralized Utility Facility (CUF) plant was designed for an average flow of 199.60 m^3/hr and the maximum hydraulic capacity of 400 m^3/hr. Peak flow of the plant was 317.1 m^3/hr. The design loading of the plant is summarized at Table 1. For an easier description, the plant consists of Splitter Box, Corrugated Plate Interceptor (CPI) Packages, Equalization Sump, Aeration Tank and Sludge Treatment (Figure 1).

Table 1. Design loading of the WWTP

Parameter	Design loading		
	m^3/hr	mg/L	kg/L
Average flow	199	-	-
Maximum flow	317	-	-
COD (Average)	-	730	146
COD (Maximum)	-	787	250
Suspended Solid (Average)	-	119	27.5
Suspended Solid (Maximum)	-	138	37.7
NH_3-N (Average)	-	-	-
NH_3-N (Maximum)	-	26	8.4
Oil (Average)	-	16	3.1
Oil (Maximum)	-	17	5.5

Integration of Influents

The backwash sump and demin effluent sump received wastewater as shown in Figure 1 (Appendix). The effluent flows through a bar screen located at the inlet chamber of the Backwash Sump before entering the sump. The screenings from the raking were collected and taken out for solid disposal. Splitter Box received waste effluent from ASGP, Backwash Sump and Demin Sump. Incoming wastewater were homogenized and split out equally to two subsequent Corrugated Plate Interceptor (CPI) units by gravity. Polymer was dosed into the Splitter Box to optimize the oil emulsion breaking, coagulation and flocculation in CPI. The Ammonia Syngas waste flows into the CPI units via the Splitter Box.

Off-Spec Flow

Controlling the nature of the waste stream is very difficult in some industries, particularly those where a range of products is produced in no particular regular quantity. In the case of a facility where the discharged waste stream was quite variable in both strength and toxic content, some form of flow or load buffering was important. Should a toxic or high load waste be detected then the waste stream is diverted to the off-spec tank whose contents can be reintroduced into the feed stream in a more dilute form. The off-spec sump was provided to temporarily receive off specification flows from CUF and/or from the customers to allow time for temporary problems to be resolved at source or allow the source to be shut down in the event that the cause is likely to persist.

The off-spec sump was designed to permit the off-spec effluents to be held, mixed and corrected and then be fed to the effluent treatment plant at a controlled rate. In addition, the off-spec sump will collect storm water.

Oil and Solid Separation

The primary function of the CPI is to reduce the oil and grease and floats loading in the aeration system downstream. The CPI is designed to separate oil and settleable solids from the effluents. Wastewater gravitates into the CPI from the Splitter Box in a laminar fashion. This wastewater contains high concentration of suspended particulate matter with some having specific gravity greater than water (e.g. settleable solids) and some less than water (e.g. grease). The accumulated primary sludge is transferred to a drum or tanker for disposal or waste to the Sludge Digester after thickening in the Sludge Thickener. The floating oil and grease are removed from the CPI and temporarily stored in the Oil Holding Tank. The CPI treated effluent flows to the Equalization Sump by gravity for further treatment. The Oil Holding Tank is used to temporarily store the floats such that it can be pumped into the Oil Storage Tank, for decanting and storage or drum/tanker for disposal. Regular removal of the settled solids is essential, as accumulation over a long period will cause the sludge to become septic. Sludge build-up in the tank, is beyond the sludge hopper capacity, will affect the performance of the CPI, causing the clogging of the coalescing plates with sludge. As a result, sludge and floats may be carried over with the CPI treated effluent, thereby overloading the subsequent activated sludge processes.

Floats are removed from the surface of the CPI by a surface skimmer and are deposited by gravity into the Oil Holding Tanks. The Oil Skimmer collects oily water, which floats on the surface of CPI, and is temporarily stored in the Oil Holding Tank.

Equalization Process

The Equalization Sump receives multiple wastewaters as shown in Figure 1. The flow and pollution load from the Acetic Acid Plant (BPPA) will be highly variable. The Acetic Acid Balancing Sumps will receive pH-neutralized effluent from the BPPA and will provide flow and pollution load balancing before the effluent is pumped to the Equalization Sump. Mixers are provided to break up stratification and keep light solids in suspension. The inlet chamber is equipped with a bar screen, and it only allows filtered wastewater to flow into the sump.

Aeration Process

The design of Aeration Tanks is a tapered aeration activated sludge treatment process. It provides greater amount of dissolved oxygen at the inlet compartment, and less dissolved oxygen at the outlet compartment. Biological treatment is accomplished in the Aeration tanks by mixing microorganisms (activated sludge) with the incoming raw wastewater.

The Aeration Tanks will receive WWTP waste pumped from the Equalization Tank via a Splitter Chamber. Microorganism inside the Aeration Tanks transforms organic loading to biomass (sludge). Mixed liquor flows to Clarifiers through overflow by gravity. Return Activated Sludge is pumped back into the Aeration Tanks from the bottom of Clarifiers to maintain MLSS level. At the Splitter Chamber, the waste is divided into two equal flows and diverted to two Aeration Tanks through the opening at the bottom of the chamber. Nutrient is dosed into the Splitter Chamber to provide necessary nutrients to the microorganisms in Aeration Tanks.

The blowers inject atmosphere air into the Aeration Tanks through diffusers to keep the activated sludge in suspension, provide sufficient mixing and supply the oxygen required for biological oxidation during the retention time provided. Alarms signals will go off when the dissolve oxygen and sludge concentration in the tank exceeds or falls below any set points.

Discharge

The Outfall Chamber (Discharge) is the final monitoring and recording unit before the treated effluent is discharged. The Outfall Chamber will receive treated wastewater from Clarifiers. The treated effluent is discharged to a common area drain. When the discharge from the Outfall Chamber does not meet the discharge standards, it will be diverted to Equalization Sump or Off Spec Sump for further treatment.

Activated Sludge

The recycle sludge pumps are designed to withdraw activated sludge settled at the bottom of Clarifiers and transfer the sludge to Aeration Tanks. The Return Activated Sludge is pumped to Aeration Tanks continuously to maintain the biomass content inside the tanks. When some quantity of biomass needs to be wasted, the sludge is withdrawn, to the Sludge Thickener as Waste Activated Sludge.

The Sludge Thickener receives primary sludge from CPI, scum and waste activated sludge from Clarifiers. A rotating floor scraper is installed at the bottom of the tank to scrap the sludge to the center sludge pocket. The Thickened Sludge is pumped to the Sludge Digestion Tank (SDT) or tanker loading. The supernatant will flow via overflow weir by gravity to the Equalization Tank. At the SDT, there are conditions provided to supply air for the microorganism and residence time for the aerobic digestion of about 50% of the residual volatile matter in the sludge. Overflows from the SDT are flowed by gravity to Equalization Tank. Digested Sludge is transferred to the SDT and later to the Sludge Centrifuge Decanter automatically.

The Dewatering process begins together with the dosing of the polymer. The Sludge Centrifuge Decanter is designed to separate water from the digested sludge prior to disposal. The Digested Sludge is pumped to the Sludge Centrifuge Decanter. The decanted sludge will fall into the Sludge Hopper by the sludge conveyer. Flushing water and decanted water are routed into the Equalization Sump for treatment. The decanted sludge will be filled into a drum.

MATERIALS AND METHODS

Auto Samplers were used to accumulate flow proportional samples from CUF and CUF customers (ASGP, VCM and BPPA). Two auto samplers were situated in the plant. One is to check the waste before entering the plant and the other is to check the Final Discharge after the clarifier. The Auto Samplers are manufactured by ISCO (Model: 3700FR).

The flow of influent as well as discharge were taken from a flow meter recorder; manufactured by Endress + Hauser (Model: FMU 861 Transmitter, FDU 80 Sensor).

The composite samples (hourly for 24 hours) were collected into a plastic container. A representative sample was then integrated by mixing portions of individual samples relative to flow rates at sampling times. Composite samples representing specified time periods were tested to appraise plant performance and loadings. Average daily BOD and Total Suspended Solid (TSS) data were used to calculate plant loading while mean influents and effluent concentrations yield treatment efficiencies [4].

On site measurement were conducted where feasible using the Hach DR/2010 Spectrophotometer. The BOD test was conducted using the APHA 5210B; TSS using method APHA 2540D, Oil & Grease using method APHA 5520B. pH meter used was of CyberScan pH 10. The method used was APHA 4500-H^{+}B; Electrometric Method. The meter is calibrated everyday using Buffer 7.0, 4.0 and 10.0 obtained from Fisher & Scientific (APHA, 1995). DO reading was obtained by using a DO Meter CyberScan DO 100. The method used was

APHA 4500-OG; Membrane Electrode Method. The zero samples were prepared by adding excess sodium sulfite and a trace of cobalt chloride, to bring the DO to zero (APHA 1995). The readings are taken insitu and noted down [5]. The COD test was done using the Hach DR/2010 Spectrophotometer (Colorimetric Determination, 0 to 1500 and 0 to 15000 mg/L COD) [5].

Samples were obtained from the aeration tank and Equalizing Sump by dipping in a bucket. The samples were poured into a 1L plastic container and transported immediately to the plant laboratory for analysis. For Oil & Grease determination, samples were poured into a 1L Glass beaker. pH, DO and temperature were done during the sampling and recorded on site. On-line monitoring consists of using temporarily or permanent installed instrumentation to measure process loading and performance parameters and a data acquisition system which collects process data, followed by analysis of the collected data [6].

Plant Performance during Commissioning

Influent Flow

Accurate flow measurement is essential for the proper operation and control of WWTP. It provides operating and performance data concerning the treatment plant, to compute costs of treatment and to obtain data for comparing treatment plant capacity with average production for planning purposes [7].

The flow rates (m^3/hr) for the incoming waste streams and final discharge from Outfall Chamber were monitored continuously by online flow meters. The average flow rates of the incoming and final discharge are shown in Figure 1 (Appendix). The data shows that the waste received by the treatment plant were mainly from CUF and VCM. ASGP has very minimum wastewater discharge in comparison with the design given throughout the testing period.

From the results, CUF have an average flow of 76.9 m^3/hr; VCM 59.7 m^3/hr; BPPA 1.0 m^3/hr and ASGP 0.5 m^3/hr (refer to Figure 1). The CUF average flow rate only reached 45% of the design flow given; VCM was almost 99.5% of the design flow; BPPA meets 80% of the design flow and lastly ASGP only reached 20% of the design flow. There was no flow observed for ASGP from Day 1 till Day 5 with a sudden surge at Day 6 and Day 7 and back to zero flow on Day 8. These complies with the given design specification of the ASGP which says that the plant shall have variable flow.

pH

The pH values for the composite samples are shown in Figure 2. Although the pH values obtained from incoming waste were occasionally out of the design specification (pH 6 – pH 9), the pH values for the final discharge at the Outfall Chamber were within Standard B Discharge Limits (pH 5.5 – pH 9.0), (Figure 2). In addition, the pH values in Aeration Tanks were very stable throughout the test. pH affects the activity of the microorganisms in a biological treatment system. The pH of the plant influent and the activated sludge mixed liquor should be checked daily to ensure that the pH in the aeration tank stays between 6.5 and 8.5.

Total Suspended Solid

Suspended materials provide adsorption sites for biological and chemical agents. Suspended solids degrade biologically and create objectionable by-products. Solids can be either suspended or dissolved in water, and are classified by their size and state, by their chemical characteristics and by their size distribution. These solids consist of inorganic or organic particles, or of immiscible liquids such as oils and greases [8].

Total Suspended Solid (TSS) in incoming wastes was much lower than the design specification. Although VCM waste had a relatively high TSS concentration, the outgoing TSS concentration at the final discharge was in compliance with the Standard B Discharge limits of 100 mg/L throughout the test (Figure 3).

TSS information is important because, generally, the first sign a treatment plant is approaching upset condition is an increase in the TSS level in clarifier. TSS levels in the plant influent are monitored in order to quantify TSS loading to the plant since TSS also contributes significantly to the organic loading to the plant.

All three plants, CUF, BPPA and ASGP have an average of 9 mg/L, 20 mg/L and 44 mg/L of TSS respectively. Compared to the design specification, the TSS value during the plant commissioning is relatively low. The VCM value meets up to 55.6% of the design requirements. Only one result showed a sudden surge of twice the design specification. The value of TSS here is abnormally high, which is 326 mg/L which could be due to error in analysis or high TSS in the incoming waste itself (Figure 3).

Oil & Grease
A variety of organic substances including hydrocarbons, fats, oils, waxes, and high-molecular-weight fatty acids are collectively referred to as oil and grease. Their importance in the industrial wastes is related to their difficulty in handling and treatment. Because of low solubility, grease separates from water adhering to the interior of pipes and tank walls, reduces biological treatability of a wastewater, and produces greasy sludge solids difficult to process [4].

The Oil and Grease concentration in incoming wastes and final discharge were below the design specification throughout the sampling period (Figure 4).

COD
The results show that the incoming COD varied significantly from day to day, thus causing the COD concentration in the Equalization Tank to fluctuate accordingly (Figure 5). Nevertheless, the final discharge, COD values are within the Standard B Discharge Limits of 100 mg/L during the test.

The COD average readings for CUF are above the allowed design specifications (Table 1). The average COD reading is 55 mg/L compared to the allowed design of 40 mg/L. The BPPA readings are far below the design specifications. The average reading only meets 0.7% of the actual design specifications. The VCM average reading of COD of 858 mg/L meets the design specifications of 900 mg/L.

DO and MLSS in Aeration Tanks
Six sampling points were assigned to each of the Aeration Tanks (A&B) in order to collectively monitor the concentration of Dissolved Oxygen (DO). During the test, one blower was operating to supply air to both the Aeration Tanks. The DO readings ranged from 2 mg/L to 6 mg/L with the average DO of 4.25 mg/L for Aeration Tank A and 4.15 mg/L for Aeration Tank B (Figure 6). The variation of DO in Aeration Tanks depended on the characteristic and chemical loading of the waste pumped from Equalization Tank into the Aeration tanks.

The DO level in an aeration basin is a very important operating parameter. If the DO in the aeration tank is too low, it will inhibit the activity of the microorganisms and result in poor BOD removal. Too high a DO could adversely affect settling in the secondary clarifier and is also an indicator that power is being wasted since more oxygen is being supplied than is needed by the bacteria. The DO concentration in the aeration tank can also be used as a process indicator. A sudden drop in the aeration tank DO level is an indication that an organic shock load has been discharged to the treatment plant and that the oxygen demand of the bacteria is greater than the amount being supplied. A sudden increase in the aeration tank DO level is an indication of acute toxicity problems. A gradual increase in DO concentration would point toward a chronic toxicity problem. The rate at which biomass takes up the dissolved oxygen from the liquid phase is actually directly linked to both the characteristics of the biomass and the quality of the substrate [9].

It is recommended that a residual of 1 to 2 mg/L of DO be maintained in the aeration tank. This will ensure that just a little more oxygen is added than is actually being utilized by the microorganisms and that the bacteria are getting enough oxygen. Excess DO also provides a buffer oxygen supply to satisfy normal variations in oxygen demand. In the event that an organic shock load is discharged to the plant and an immediate oxygen demand higher than normal is exerted by the bacteria, the excess supply of DO helps, at least, to satisfy the demand [10].

Mixed Liquor Suspended Solid concentration (MLSS) in the Aeration Tanks (A&B) was analyzed daily (Figure 7). The data obtained ranged between 1100 mg/L to 2000 mg/L. The average MLSS value during the test was 1690 mg/L for both the Aeration Tanks. The online Sludge Concentration Meters were used to monitor the sludge concentration. The readings from the online Sludge Concentration Meter are used to monitor MLSS concentration in Aeration Tanks, an provide an alarm in the event of, for example, all the sludge starting to settle at the bottom of the Aeration Tanks due to blower failure.

Full Standard B Analysis

Two sets of samples were collected for full Standard B analysis: one on the first day and the other on the last day of commissioning. These two samples consist of composite samples from each of the incoming waste (CUF, BPPA and VCM), the Equalization Tank and the Discharge. The Standard B Limits and analysis data from the client laboratory are tabulated in Table 2 and Table 3.

From first day analysis results, the Arsenic concentration for the Outfall Chamber composite sample is 0.211 mg/L. At the same time, it was recorded the presence of Arsenic in incoming effluent streams, particularly VCM effluent. The CUF WWTP is not designed with the specific purpose of removing Arsenic.

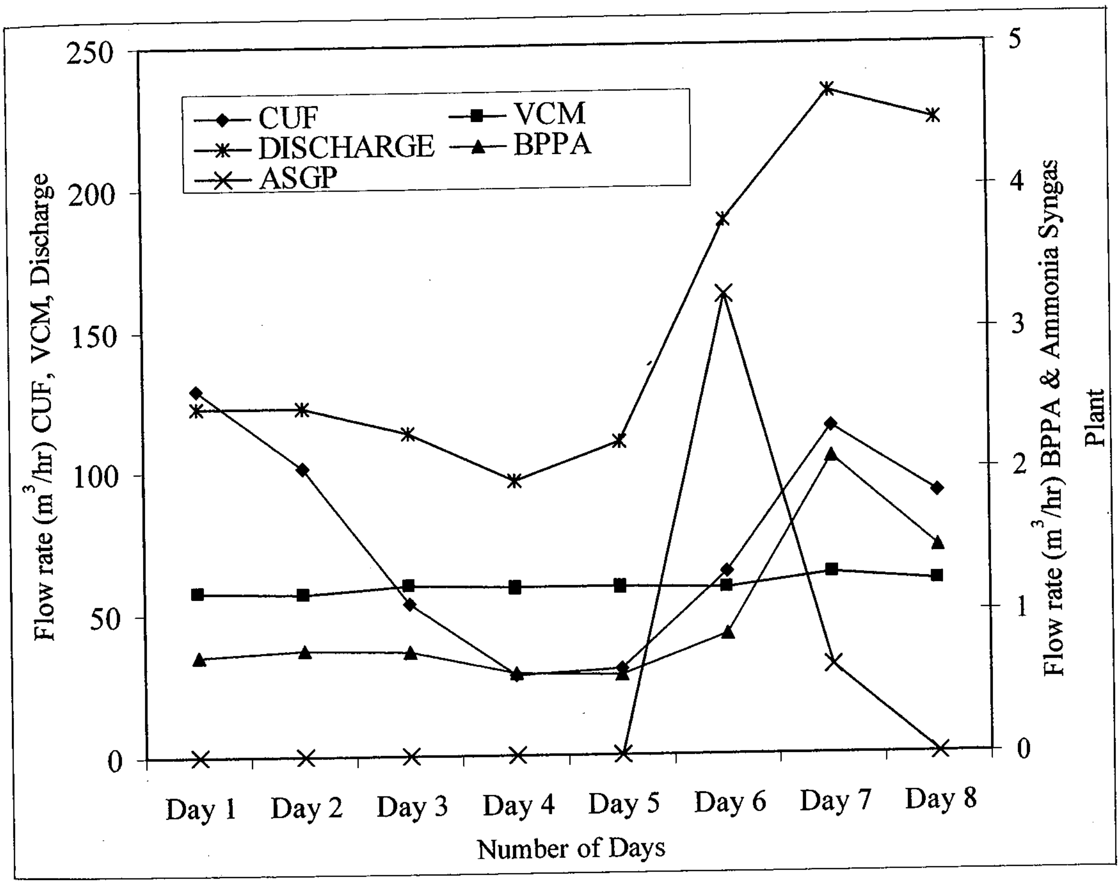

Figure 1. Flow rate (m^3/hr) vs. Incoming Wastewater and Discharge

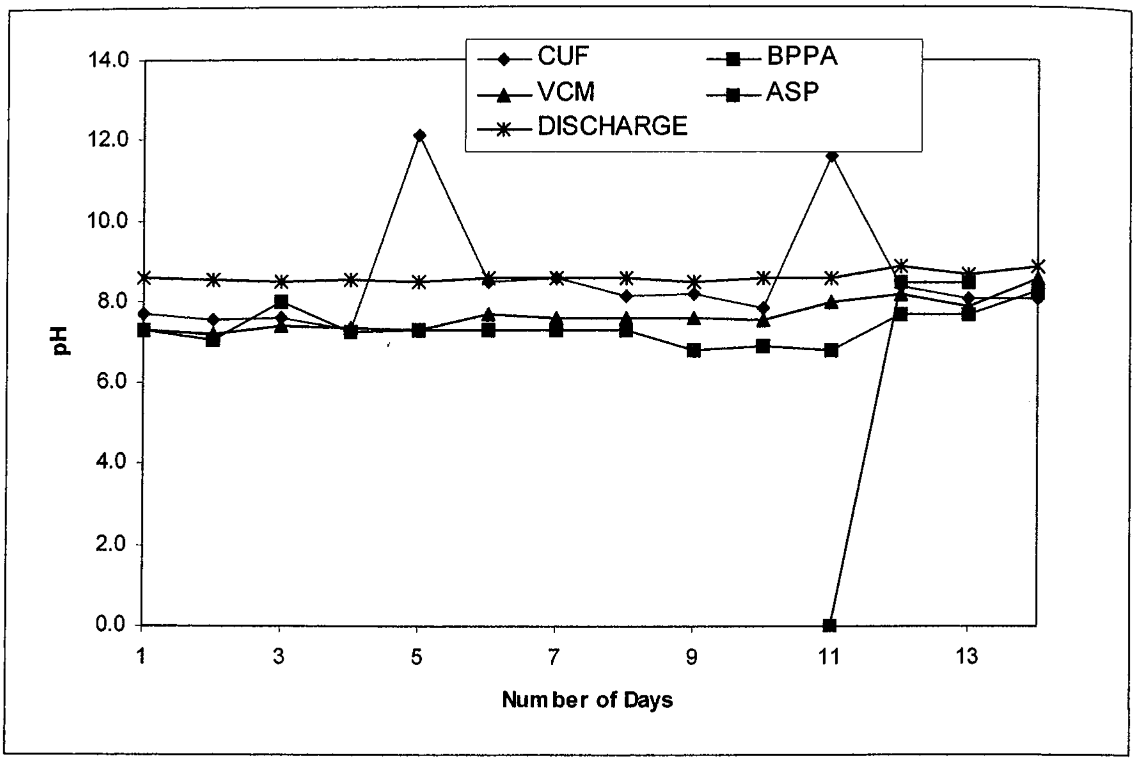

Figure 2. pH Reading for Incoming Wastewater and Discharge During Commissioning

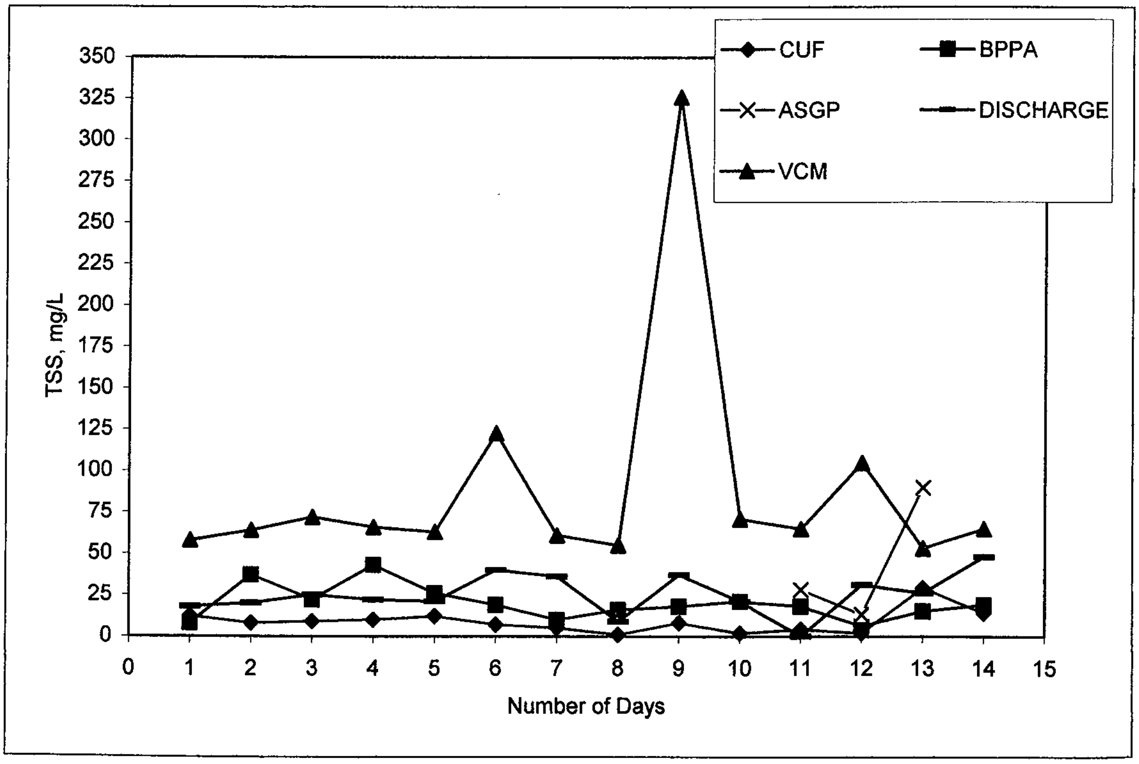

Figure 3. TSS Of Incoming Wastewater and Final Discharge

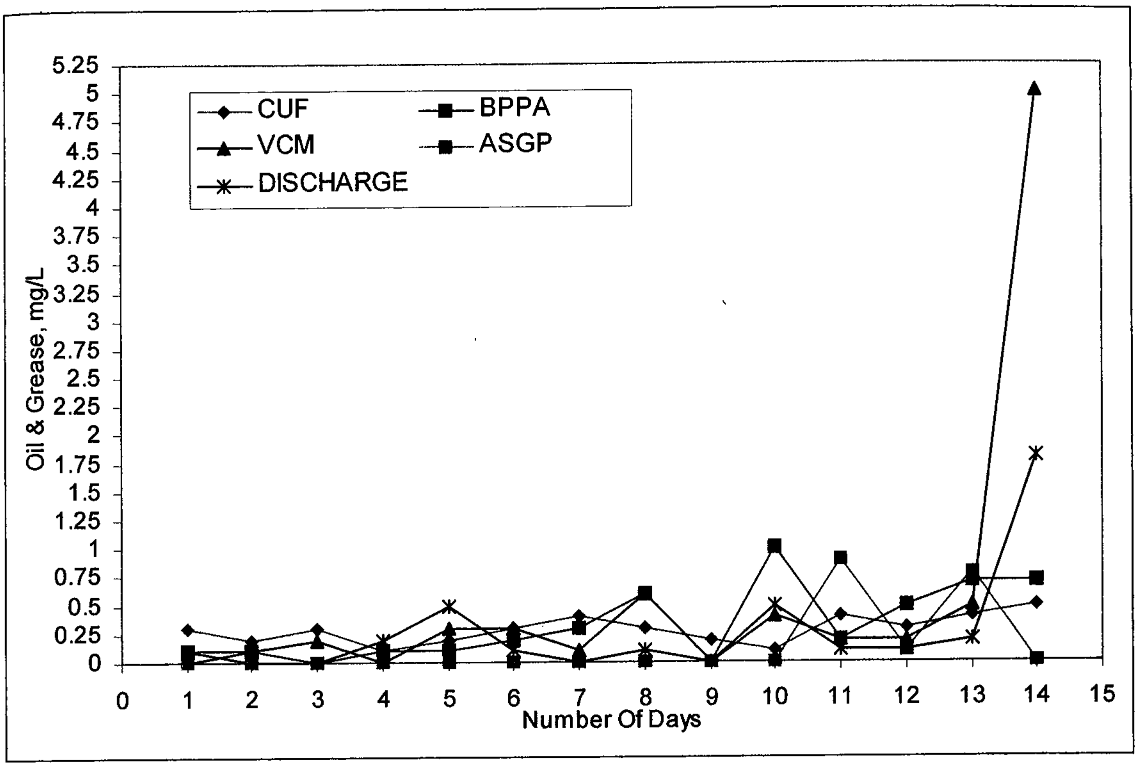

Figure 4. Oil and Grease Measurement for Composite Samples

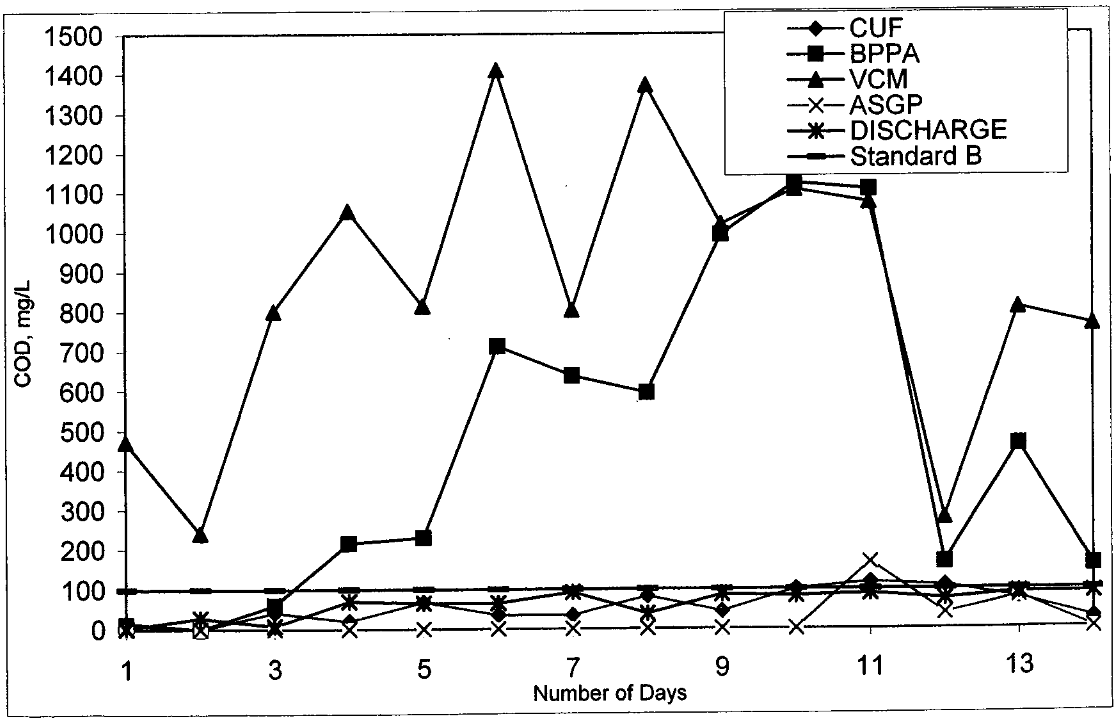

Figure 5. COD Reading of Incoming Wastewater and Discharge

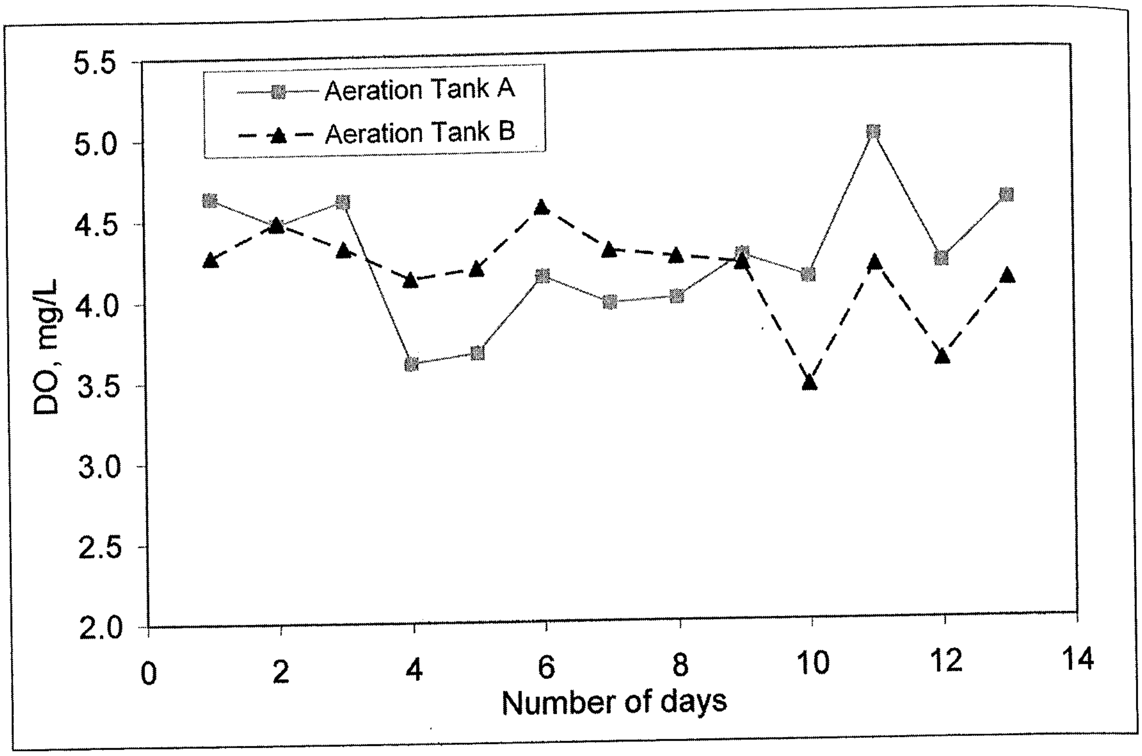

Figure 6. DO (mg/L) Measurement for Aeration Tanks (A & B)

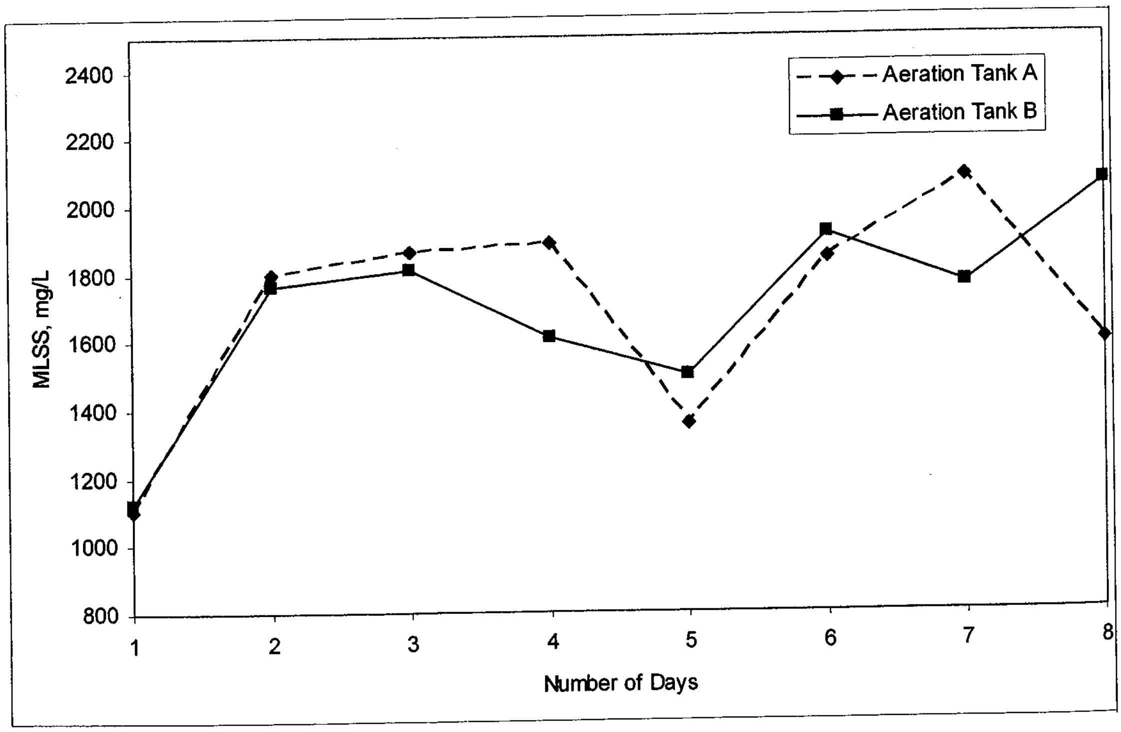

Figure 7. MLSS (mg/L) Measurement for Aeration Tank (A & B)

Table 2. Full Standard B Analysis (All units in mg/L) First Day

Parameter	Standard B	CUF	BPPA	VCM	ES	Discharge
Mercury (Hg)	0.050	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium (Cd)	0.020	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (C^{r6+})	0.050	0.014	0.003	0.0004	0.020	0.011
Arsenic (As)	0.100	BDL	0.144	BDL	BDL	BDL
Cyanide (CN)	0.100	<0.05	<0.050	<0.050	<0.050	<0.05
Lead (Pb)	0.500	0.081	0.107	0.025	0.126	<0.05
Chromium (Cr^{3+})	1.000	0.002	0.033	0.039	0.015	0.025
Copper (Cu)	1.000	0.015	0.011	0.118	0.017	0.088
Manganese (Mn)	1.000	0.008	0.007	BDL	BDL	BDL
Nickel (Ni)	1.000	0.010	<0.009	0	0.002	0.004
Tin (Sn)	1.000	<0.030	<0.03	<0.030	<0.030	<0.030
Zinc (Zn)	1.000	0.055	0.129	0.042	0.038	0.078
Boron (B)	4.000	<0.001	<0.001	<0.001	<0.001	<0.001
Iron (Fe)	5.000	0.256	0.659	1.388	0.344	0.193
Phenol (Ph)	1.000	<0.020	<0.020	<0.020	<0.020	<0.020
Sulphide (S)	0.500	<0.010	<0.010	<0.010	<0.010	<0.010

Note: BDL means Below Detectable Limit

Table 3. Full Standard B Analysis (All units in mg/L) Eight Day

Parameter	Standard B	CUF	BPPA	VCM	ES	Discharge
Mercury (Hg)	0.050	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium (Cd)	0.020	0.012	0.012	0.012	0.003	0.015
Chromium (Cr^{6+})	0.050	<0.003	<0.003	<0.003	<0.003	<0.003
Arsenic (As)	0.100	0.080	0.06	0.282	0.019	0.211
Cyanide (CN)	0.100	<0.05	<0.050	<0.050	<0.050	<0.050
Lead (Pb)	0.500	<0.05	<0.050	<0.050	0.037	<0.050
Chromium (Cr^{3+})	1.000	<0.003	<0.003	<0.003	<0.003	<0.003
Copper (Cu)	1.000	0.015	<0.030	<0.030	0.002	0.037
Manganese (Mn)	1.000	0.050	0.034	0.034	0.024	0.040
Nickel (Ni)	1.000	<0.009	<0.009	<0.009	<0.009	<0.009
tin (Sn)	1.000	<0.030	<0.03	<0.030	<0.030	<0.03
Zinc (Zn)	1.000	0.090	1.562	1.562	0.025	0.091
Boron (B)	4.000	0.019	<0.001	<0.001	0.001	<0.001
Iron (Fe)	5.000	0.725	0.454	0.454	0.344	0.189
Phenol (Ph)	1.000	<0.020	<0.020	<0.020	<0.020	<0.020
Sulphide (S)	0.500	<0.010	<0.010	<0.010	<0.010	<0.010

Note: BDL means Below Detectable Limit

RESULT & DISCUSSION

Trouble Shooting

There are a wide variety of common operational and mechanical problems that can occur periodically to prevent the proper treatment of raw water at a conventional WWTP. A few standard operating conditions that need to be followed during trouble shooting will be discussed here.

If pH monitored is over the range, either below or above the effluent standards (5.5 – 9.0), the off spec waste is diverted to the Off-Spec sump. The pH is adjusted with acid (HCl, 37% or caustic, NaOH 45%). If the temperature is in the over range, the waste is diverted to the Off –Spec Sump to let the waste circulate and to cool down. This will lower the temperature before further treatment commences. If the salt content and organic loading is in the over range, the waste is diverted to the Off Spec Sump. It is transferred back to the Equalization Sump, and diluted with low strength waste.

If the CUF Plant has an operation shutdown, it would not alarm the plant, as it is of a low strength waste. BPPA Plant shutdown will cause a COD deficiency in the Aeration Tank. There are two Total Oxygen Demand Meters (TOD), one for BPPA and the other for VCM, installed to monitor the TOD concentration. The TOD concentration was monitored continuously for BPPA and VCM due to the high organic pollutant loading from these sources. From the pH and TOD analysis results, the pollutant loading if within the acceptable range, the flow was directed to the Equalization Sump. If the pollutant loading is out of the acceptable range, the flow is directed to the Off Spec Sump.

Chemicals used for seeding here was Ethylene Glycol (EG), Acetic Acid and Sugar with the following ratio: - [1kg EG: 1.29 kg COD; 1kg Acetic Acid: 1.08 kg COD and 1kg Sugar: 2.5 COD]. The same procedure was used during the VCM plant shutdown.

During the ASGP plant shutdown, the plant will experience Ammonia concentration deficiency; therefore the nutrient dosing was adjusted. Furthermore the polymer dosing was adjusted for the CPI dosing too. Nutrient dosing follows the ratio of COD: N: P: 100: 5: 1. The polymer dosing was adjusted using the Jar Test results [11].

CONCLUSION AND RECOMMENDATIONS

Based on the results obtained from the Performance Test, the quantity and the quality of the treated effluent at the Final Discharge meet Standard B Discharge Limits.

In conclusion, an integrated approach of building one WWTP for treating a few industries can be successful with proper implementation and plant design. The results show that four different types of industries (CUF, ASGP, BPPA and VCM) can share one common WWTP. In doing so these industries have saved the cost of building four different types of WWTP. This type of practice leads to better wastewater management. In the twenty-first century, the effective management of all wastewater will become a critical issue, especially as the world's demand of material continues to increase. Thus, instead of providing one WWTP for the protection of the environment, an integrated system can and will play a vital role in wastewater management and sustainability in the future.

To continue operating the plant according to the design specification, the following recommendations are suggested: -

1. CUF Effluent Treatment Plant did not continuously comply with the Arsenic limit. It is not clear whether this is due to Arsenic in the CUF or customer effluents, Cooling Water Blowdown, digester supernatant or due to sampling and analytical error. To resolve this issue, the client should carry out a detailed analytical campaign to identify the source and then resolve this.
2. The high variation of pH and chemical loading inhibits the growth of biomass in the Aeration Tanks (A and B). The dampening of these variations depends on the availability of dilution factor and buffer capacity (i.e. empty volume of Off Spec Sump) of the plant. Close monitoring of the incoming waste is required such that Off-Spec waste is diverted into the Off Spec Sump and fed into the biological treatment tanks in a controlled and diluted manner.

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