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A Study of Performance of Wastewater Treatment Systems for Small Sites

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***Abstract*—**The pollutant removal efficiency of the Intermittently Decanted Extended Aeration (IDEA) wastewater treatment system at Curtin University Sarawak Campus, and conventional activated sludge wastewater treatment system at a local resort, Resort A, is monitored. The influent and effluent characteristics are tested during wet and dry weather conditions, and peak and off peak periods. For the wastewater treatment systems at Curtin Sarawak and Resort A, during dry weather and peak season, it was found that the BOD_5 concentration in the influent is 121.7mg/L and 80.0mg/L respectively, and in the effluent, 18.7mg/L and and 18.0mg/L respectively. Analysis of the performance of the IDEA treatment system showed that the operational costs can be minimized by 3%, by decreasing the number of operating cycles. As for the treatment system in Resort A, by utilizing a smaller capacity air blower, a saving of 12% could be made in the operational costs.

***Keywords*—**Conventional Activated Sludge, IDEA, Performance Monitoring, Wastewater Treatment

I. Introduction

RAPID population and industrial growth has debilitated various ecosystems in the last century. According to the World Health Organization (WHO) and UNICEF, there are over 2.6 billion people facing various water crises and sanitation problems [1]. The scarcity of clean water incapacitates basic survival and hygienic practices, such as drinking and bathing. In Malaysia, about 6 million tonnes of sewage is generated each year [2]. Rapid population growth, expansion of cities and industrial development has contributed to a large amount of domestic and industrial wastewater. However, many of the current wastewater treatment plants in Malaysia are underperforming and overloaded, and are unable to produce treated effluents that would meet the Malaysian discharge standards [2]. The untreated wastewater (which incorporates stormwater) can impose loads onto the receiving waters, eventually affecting the ecosystem and also public health. Due to rapid developments in industry, profits are maximised by manufacturing great volumes of product. The toxic and hazardous wastewater discharged from industrial activities in Malaysia in 1992 was 337000 tons annually [3]. Thus, industrial wastewater contributes significantly towards water pollution in Malaysia as well.

In order to improve water quality and solve the sanitation problem, implementation of wastewater treatment systems is necessary to treat wastewater and protect public health, as well as the environment. Pathogens and pollutants from wastewater constituents will cause harm to human health, and nutrients from wastewater may lead to eutrophication that would damage aquatic life. To design adequate and effective wastewater treatment systems, the design capacity of treatment plant needs to be determined from the flow and constituent characteristics of the raw wastewater. Factors that can influence quantity and quality of wastewater that is discharged from small sites such as domestic and institutional sources include function, location, characteristics of residents, and water-using fixtures and appliances [4]. Wastewaters that are generated from different sites represent different wastewater generation patterns, flows and constituents [5]. Domestic wastewater generation has been well established [6]. However, studies on wastewater and stormwater characteristics for small sites such as institutional or stand-alone commercial sources such as resorts are not commonly established in Malaysia [5]. Therefore, a practical study of the wastewater characteristics for these institutional and stand-alone commercial sources is necessary. Characteristics of non-residential wastewaters should be estimated based on available data from similar facilities [6].

This paper presents a study of the performance of wastewater treatment systems for the small sites of a university, namely Curtin University Sarawak Campus (Curtin Sarawak) located in Miri, Sarawak, Malaysia; and a local resort (Resort A) in Miri. The wastewater treatment systems at the two sites are the Intermittent Decanted Extended Aeration (IDEA) Activated Sludge Wastewater Treatment System in Curtin Sarawak, and a conventional activated sludge wastewater treatment system in Resort A. Characteristics of the influent and effluent are tested, focusing on water quality parameters such as total suspended solids (TSS), Biochemical Oxygen Demand (BOD), ammonia nitrogen (NH_3-N), total phosphates (TP), total chlorine, pH, temperature and dissolved oxygen (DO). All of these characteristic of wastewater are compared with the Malaysian environmental effluent guidelines and design aims of the two wastewater treatment systems. By studying the influent and effluent, the treatment efficiency of the two treatment systems may be evaluated. The efficiency of the wastewater treatment systems are also evaluated during peak and off peak periods to determine their performance, especially during peak periods. To complete the study, previously produced wastewater generation patterns for Curtin Sarawak are also presented.

In order to improve the performance of the wastewater treatment systems, steps can be taken to optimize the design and operation of the wastewater treatment system. It has been shown that various approaches could be taken to optimise the wastewater treatment, but mostly, an informal approach is taken where the initial values of the decision variable is estimated by the trial and error method, then update [7]. Examples of optimisation of wastewater treatment systems include manipulation of the dissolved oxygen and sludge age [8], the use of Commercial Activated Carbon (CAC) or mixed

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adsorbent carbon (MAC) [9], online BOD monitoring [10] and others. This study presents an analysis of the wastewater treatment systems carried out to minimize operation costs, and maintain the performance of the treatment systems. Cost saving measures could include shortening unnecessary operation hours of components of the wastewater treatment system such as lighting and cooling fans. Variables to be monitored and optimised include the duration of operation, electricity consumption and calculated power consumption of the pumps in the wastewater treatment system.

II. Methodology

Water quality testing is carried out to monitor the influent and effluent quality of wastewater treatment systems for Curtin Sarawak and Resort A. These laboratory testings are performed using the Hach self-contained Surface Water Test Kit. The 5-day Biochemical Oxygen Demand (BOD_5) test is also performed, according to the Standard Method for the Examination of Water and Wastewater 5210: Biochemical Oxygen Demand, published by American Public Health Association (APHA), American Water Works Association, Water Environment Federation (1999). Due to space constraints, the standard methodologies for these tests are not presented here. The water quality parameters monitored include 5-day Biochemical Oxygen Demand (BOD_5), dissolved oxygen (DO), pH, temperature, Nitrate, Ammonia Nitrogen, Orthophosphate, Total & Free Chlorine and Fecal coliform test. The collected laboratory results will be compared with the design capacity of treatment plants as shown in the manual of the treatment plants.

For Curtin Sarawak, the influent is sampled at the entry point of the IDEA treatment system, while the effluent is sampled at the effluent pipe, which discharges effluent into an open channel which leads to the receiving retention pond. Sampling is not carried out in the receiving water. As for Resort A, the influent is sampled at the sand trap of the conventional activated sludge treatment system, while the effluent is sampled at the weir in the sedimentation tank. The water quality monitoring and sampling was performed according to seasonal variations and weather conditions as shown in Table 1. Wastewater quality and quantity has been shown to be dependent on seasonal and diurnal variations [11]. The monitoring regime, incorporating four different periods of monitoring are shown in Table 1 below.

TABLE I
WATER QUALITY MONITORING REGIME (INCORPORATING SEASONAL VARIATIONS)

Seasons	Curtin University Sarawak Campus; Miri, Sarawak, Malaysia	Resort A; Miri, Sarawak, Malaysia
Wet weather	Sampled three days after continuous rain	Sampled three days after continuous rain
Dry weather	Sampled after one week without rain	Sampled after one week without rain
Peak season	All classes from the School of Engineering, School of Business and School of Foundation and Continuing Studies in the University ongoing, with all staff in campus	About 330 guests, based on 75% occupancy rate (of a total of 220 rooms), assuming two persons in each room.
Off peak season	Semester break periods, with only about 350 staff members in the University	About 264 guests, based on 50% occupancy rate (of a total of 220 rooms), assuming two persons in each room

Wastewater generation patterns for Curtin Sarawak from a previous study [5] are also presented here to demonstrate the dependence of generation patterns to the activity of the residents. To produce the wastewater generation patterns, it is assumed that the volume of water consumption is equal to the volume of wastewater generated [11]. Hence, water meter readings were monitored and recorded to quantify water consumption and generate wastewater generation patterns, from 7 am to 7 pm daily with a time interval of 1 to 3 hours, for one week for different seasons. Since the water meter readings for the duration from 7 pm to 7 am the next day were not taken, the data in between the duration were interpolated.

III. Performance of Wastewater Treatment Systems

A. Curtin Sarawaks: Intermittent Decanted Extended Aeration (IDEA) Activated Sludge Treatment System

The design capacity of the sewage treatment system is listed in Table II [12]. It consists of 9 components – inlet/ screen chamber, pumping station, secondary screen chamber, horizontal constant velocity grit chamber, grease chamber, demand aeration tank, intermittent aeration tank, sludge holding tank and flow measurement chamber. The process flow is shown in Figure 1.

TABLE II
DESIGN CAPACITY OF THE IDEA ACTIVATED SLUDGE WASTEWATER TREATMENT SYSTEM [12]

Population equivalent	1800 persons
Average sewage flow	405m^3/day
Peak sewage flow	1782m^3/day
Influent BOD5 concentration	250mg/L
Influent SS concentration	300mg/L
BOD5 loading	101.25 kg/day
Design aim of treated effluent (BOD_5)	10mg/l
Design of treated effluent (SS)	20mg/L

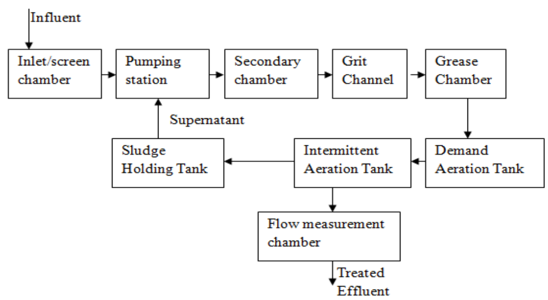

Fig. 1 Process flow chart of the IDEA activated sludge wastewater treatment system

Sampling was carried out as described in the previous section. The water quality measurements during the peak and off peak periods of the wet and dry seasons are presented in Table 3. From Table III, the removal of BOD_5 is quite effective, with a maximum removal of about 91% during the dry weather off peak period, and a minimum removal of 69% during the wet weather peak period. The effluent BOD_5 during the off peak periods of both wet and dry weather are less than the design treatment aim of 10mg/l. However, effluent BOD_5 during the peak periods of both wet and dry weather exceeded the design treatment aim. Moreover, weather affects the strength of the raw wastewater. During dry weather, the BOD_5 of the raw wastewater is almost twice the BOD_5 of the raw wastewater in wet weather. Ammonia nitrogen levels are high, with low removal percentages, ranging from 2 – 10%. Thus, with such low removal percentages across all weather conditions and periods, an unhealthy amount of ammonia nitrogen which could lead to the occurrence of eutrophication is released into the receiving water. However, there is no discernable nitrate concentration in the influent and effluent. Due to nitrification processes, the ammonia could be converted to nitrate further downstream, and sometime after release. As the aim of this study is to monitor pollutant removal in the effluent, the receiving water body is not tested. It is suggested here the further monitoring could be carried out for nitrate within the receiving water body. DO levels are acceptable. The influent and effluent suspended solids were not monitored during this study, due to unavailability of laboratory equipment.

Consultation with the Curtin Sarawak service technician revealed that there are components installed in the IDEA treatment system that are not functioning well, at the time of the study [13]. These included two units of aerators in the demand aeration tank, one unit of aerator in the intermittent aeration tank and the returning activated sludge (RAS) pump in the intermittent aeration tank. According to Commodity Supplier Sdn. Bhd., the return sludge transferred from secondary treatment to primary treatment should be in the range of 5 – 30% of wastewater flow [14]. Since the return sludge pump (RAS) is not working, the organic material or Mixed Liquor Suspended Solids (MLSS) is clearly not sufficient for efficient treatment in the aeration tank.

The results indicate that water consumption is proportional to seasonal variation, which for an institution of higher learning, like Curtin Sarawak, would be the variation between the commencement of classes and during holidays where there are no classes [11]. Peak and off peak periods for Curtin Sarawak have been defined in Table 1. Higher population leads to higher water consumption, and greater discharge of wastewater into the wastewater treatment system, with correspondingly higher concentrations of BOD_5 during the peak season [5]. This is shown in Table 4, which presents the maximum volume of water consumed per day as estimated from the water meters from a study presented in reference [11]. Variation is clearly seen for the teaching weeks against the non-teaching weeks.

TABLE III
WATER QUALITY MONITORING RESULTS FOR IDEA ACTIVATED SLUDGE WASTEWATER TREATMENT SYSTEM

Test	Dry Weather Peak		Dry Weather Off Peak		Wet Weather Peak		Wet Weather Off Peak	
	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.
BOD_5 (mg/l)	121.7	18.7	90	8.2	66.5	20.71	46	5.8
DO (mg/l)	8.02	8.0	8.05	8.01	8.02	7.99	7.98	7.71
pH	7.4	7.4	7.1	7.1	7.3	7.3	7.2	7.2
Temperature (°C)	29° C	29° C	28° C	29° C	26° C	28° C	27° C	29° C
Nitrate (mg/l)	0	0	0	0	0	0	0	0
Ammonia (mg/l)	5.0	4.5	5.0	4.5	4.4	4.3	4.5	4.3
Orthophosphate (mg/l)	10.0	5.3	10.2	5.2	9.8	5.0	10.0	5.3
Total and free chlorine (mg/l)	0	0	0	0	0	0	0	0
Fecal coliform	Positive, MPN/100ml = 16, not acceptable quality							

TABLE IV
WATER CONSUMPTION DURING PEAK AND OFF PEAK PERIODS FOR IDEA WASTEWATER TREATMENT SYSTEM [11]

	Teaching week (Semester 1)	Teaching week (Semester 2)	Non-Teaching week (Semester Break)
Maximum weekday consumption (m^3/day)	200.5	154	135.8
Saturday consumption(m^3/day)	125.1	112.9	123.1
Sunday consumption (m^3/day)	98.5	79.6	113.1

B. Curtin Sarawak Wastewater Generation Patterns

In this section, selected results from a study on wastewater generation patterns [5] in Curtin Sarawak are presented to demonstrate the relationship between residents' activities to wastewater generation. Generally, the wastewater flow rate is determined from a water consumption graph. In many international surveys, water consumption is used as an indicator of the wastewater production as it is assumed that tap water, once used, will become wastewater and discharged to the wastewater systems [15]. In this study, it is assumed that the volume of water consumed is equal to the volume of wastewater discharged. In order to investigate and compare water consumption volume and patterns during different seasons, water meter data from a teaching week in Semester 1, 2008 and a week during the semester break in Semester 1, 2008 are presented here.

The hourly variation of water consumption for a day in Curtin Sarawak for Week 8 (teaching week) of Semester 1, 2008 (April 13 – 19, 2008) is shown in Figure 2. It is noticeable that only one peak of water consumption occurred daily during the weekdays as shown Figure **2**. This pattern is different from water consumption (and wastewater generation) patterns for domestic sources, which exhibit two peaks during the course of a day [6]. The peak of hourly water consumption during weekdays ranges between 34 m^3 to 40 m^3, compared to 14 m^3 and 23 m^3 for Saturdays and Sundays respectively. As for total water consumption, there is no significant difference each weekday, with total volume ranging from 150 m^3 to 160 m^3. The water consumption on Saturday and Sunday is about 100 m^3 and 64 m^3 respectively, which is lower than the water consumption during weekdays. This is expected since no classes are in session during the weekends.

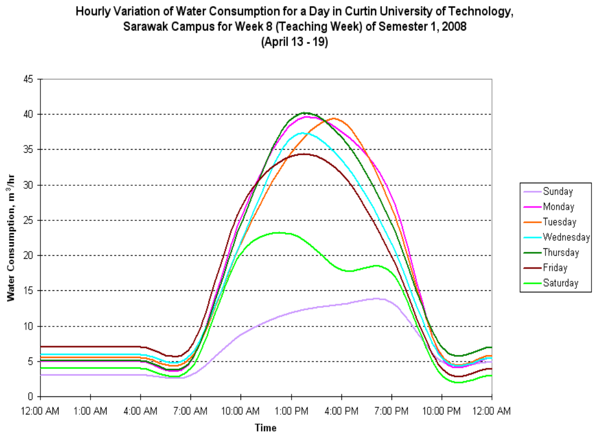

Fig. 2 Hourly variation of water consumption in Curtin University Sarawak Campus for Week 8 of Semester 1, 2008 (April 13 – 19, 2008)

The hourly variation of water consumption (and wastewater generation) for a day in Curtin University Sarawak Campus for the Semester 1, 2008 semester break (June 22 – 28, 2008) is shown in Figure 3. The peaks of hourly water consumption during weekdays are higher than water consumption during weekends, ranging from about 30 m^3 to 34 m^3 during weekdays, and 14.5 m^3 and 15.5 m^3 on Saturday and Sunday respectively. As for total water consumption, the water consumption during weekdays (140 m^3 to 150 m^3) is higher than water consumption during weekends (85 m^3 to 90 m^3).

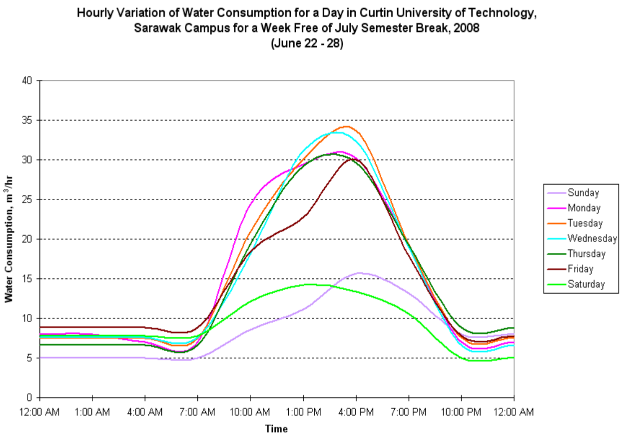

Fig. 3 Hourly variation of water consumption for a day in Curtin University Sarawak Campus for a week free of July Semester Break, 2008 (June 22 – 28, 2008)

From the wastewater generation patterns, diurnal and seasonal variations are evident. For Curtin Sarawak, the diurnal variation of water consumption is different from established from domestic diurnal patterns. There is one peak of hourly water consumption that generally occurs between 12 noon to 2 pm. It may be caused by the lunch period for students and staff. For the domestic diurnal patterns, another peak will occur in the evening due to household activities such as bathing, preparation of the evening meal, cleaning and others [6]. Seasonal variation in the water consumption and wastewater generation can also be observed, with less volume of water consumed during off peak periods such as the semester break. Therefore, both diurnal and seasonal variation for water consumption is strongly dependent on population and on-going activities.

C. Resort A: Conventional Activated Sludge Treatment System

Two units of the conventional activated sludge wastewater treatment system is used in Resort A. Each unit caters for a population equivalent of 500 persons. According to design manual provided by Commodity Supplier Sdn Bhd. [14], the design of the treatment system is based on information as presented in Table 5. The conventional activated sludge wastewater treatment system consists of 6 components, which include a coarse screen, an equalization tank, a fine screen, an aeration tank, a sedimentation tank and a sludge concentration tank as shown in Figure 4.

TABLE V
DESIGN CAPACITY OF THE CONVENTIONAL ACTIVATED SLUDGE WASTEWATER TREATMENT SYSTEM CAPACITY

Influent 5-day Biochemical Oxygen Demand (BOD_5)	250mg/L
Influent Total Suspended Solid (TSS)	300mg/L
Effluent 5-day Biochemical Oxygen Demand (BOD_5)	20mg/L
Effluent Total Suspended Solid (TSS)	30mg/L

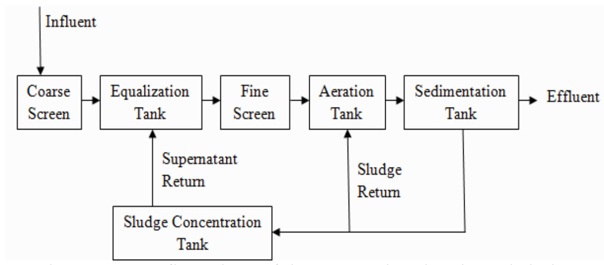

Fig. 4 Process flow chart of the conventional activated sludge wastewater treatment system

As shown in Table VI, it is observed that the concentration of BOD_5 had been reduced. The concentration of BOD_5 during all weather conditions and peak and off peak periods monitored are under the effluent design aim of 20mg/l, which indicates that the system is working well. However, orthophosphate levels are quite high, perhaps originating from various detergents used for laundry in the hotel. Ammonia levels are lower than the IDEA wastewater treatment system, but still significant. Similar to the IDEA wastewater treatment system, BOD_5 concentration for the peak season is much higher than for the off peak season. As defined earlier, peak season occurs during weekends and public holidays while off peak seasons occur during weekdays. During the peak season, room occupancy stands at about 60-75%, and is about 50 – 65% during off peak seasons. Similarly, raw wastewater contained higher concentrations of BOD_5 during dry weather. Upon consultation with the contractor in charge of maintenance of the conventional activated sludge wastewater treatment system [16], there is one unit of air diffuser in the equalization tank which is not functioning.

TABLE VI
WATER QUALITY MONITORING RESULTS FOR RESORT A

Test	Dry Weather				Wet Weather			
	Peak		Off Peak		Peak		Off Peak	
	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.
BOD_5 (mg/l)	80.0	18.0	20.1	14.0	40	12	18.0	10.0
DO (mg/l)	8.02	7.85	7.83	7.6	8.0	7.8	7.82	7.70
pH	7.2	7.3	7.3	7.4	7.2	7.2	6.8	6.8
Temperature (°C)	27° C	28° C	28° C	29° C	27° C	27° C	26° C	26° C
Nitrate (mg/l)	0	0	0	0	0	0	0	0
Ammonia (mg/l)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Orthophosphate (mg/l)	9.9	7.0	10.0	7.0	9.8	7.0	10.0	7.0
Total and free chlorine (mg/l)	0	0	0	0	0	0	0	0
Fecal coliform	Positive, MPN/100ml = 16, not acceptable quality							

IV. OPTIMIZATION OF WASTEWATER TREATMENT SYSTEMS

In this study, optimization for wastewater treatment systems is defined as maximising efficiency while minimizing the operation cost, as shown in reference [17]. The aim is to optimize or maximize the performance of the two current wastewater treatment systems while maintaining its original structure and design. With optimization, energy consumption can be reduced and operating costs can be minimised.

A. Curtin Sarawak: IDEA Wastewater Treatment System

When the aeration tank and sedimentation tank are not provided with sufficient oxygen, the amount of microorganisms in the activated sludge will decrease. As a result, failure of the biological process will occur, leading to poor effluent quality for the plant. Here, the focus will be increasing the amount of oxygen in the demand aeration tank (DAT) and intermittent aeration tank (IAT). The assumption for the DAT and IAT is that $1m^3$ of wastewater requires $1m^3$ of oxygen [14].

The specification of the aerator is 1kg O_2/kw-hr, with a power output of 3kw-hr [12]. Thus, each aerator produces 3kg O_2/kw-hr. The average flow of the wastewater is $405m^3$/day (or $0.28m^3$/min), as stated in Table 1. For oxygen at standard temperature and pressure (STP) of 25°C and pressure of 1 atm, the air density is $1.184kg/m^2$. For 1 hour of operation, wastewater flow is $16.8m^3$/hour, while the aerator is able to produce 3kg O_2. Therefore, conversion of the 3kg O_2 into volume yields $2.63m^3$ O_2. As a result, an hour of operation will require 16.8/2.63 = 6 units of aerators.

Based on observations, there are only five units out of six units of aerators functioning. The aerator in IAT operates for 12 hours daily. From the design manual [12], one operating cycle in the IAT during peak flow, which includes aeration, settling and decanting, takes place within 169 mins. Therefore, there are 4 operating cycles for the each day (12 hours operation, 169 min per cycle). Based on Hii [5] and Tan [11], the design flow of the IDEA wastewater treatment system is estimated to range from $160m^3$/day to $200m^3$/day. Taking an assumption of an average of $180m^3$/day, the number of operating cycles is required for intermittent aeration tank is $180m^3/(0.28m^3/\text{min} \times 265) = 3$ cycles.

From the analysis, only 3 operating cycles are required for wastewater treatment each day. The estimated operating cost, based on the electricity tariff at the time of analysis for the current operation of 4 operating cycles in the IAT is RM1678.32 per month. With 3 operating cycles, a modest saving of 3% is possible with the operating cost lowered to RM1630 per month.

B. Resort A: Conventional Activated Sludge Wastewater Treatment System

Currently, the oxygen is provided into the aeration tank by the air blower through the air diffuser. According to design manual provided by Commodity Supplier Sdn. Bhd. [14], the aeration required is $O_2 = aLr + bSa$, where the oxygen required is calculated in terms of kg per day. The BOD eliminated coefficient, a, is 0.5 kg O2/kg BOD. Lr is total BOD removal, where it is 20.3 kg/d, assuming 90% BOD removal. The sludge endogenous coefficient is 0.07 kg O_2 / (kg MLVSS.d), and Sa is Mixed Liquor Volatile suspended solids (MLVSS) which is calculated to be 73.95kg, based on the capacity of the aeration tank. Therefore, the aeration required is 15.33kg/d. With solubility of air in sewage of 5%, and oxygen content in air of 0.277 kg per m^3 of air, the volume of air required is $15.33 \times 100 / (0.277 \times 5) =$ 769L/min. Accounting for 30% losses, the total volume of air required is 1000L/min. The air blower used in the wastewater treatment system has the air discharge rate of 1800L/min. Therefore, it is suggested that the current air blower be replaced with a smaller capacity air blower, minimising operating costs.

The operating cost for a smaller air blower is RM1037.23 per month (based on electricity tariff at the time of analysis) compared to the current total operating cost of RM1173.30 per month. In addition, an energy saving of 216kw/month (12% of energy consumption for operation) is possible.

V. DISCUSSION

Sampling procedures should be designed to ensure that the small fraction of the stream sampled is representative of the entire stream [18]. In this study, the influent and effluent of both wastewater treatment systems were sampled directly, and no sampling was carried out for the receiving water. Due to the high observed values of ammonia and orthophosphate for both wastewater treatment systems at Resort A and Curtin Sarawak, a sampling regime for the receiving water body will be established in future studies. High levels of nitrogen and phosphorus in the treatment effluent could lead to high concentration of these nutrients in the receiving water, setting up ideal conditions for eutrophication, which would damage its ecosystem.

From the study, the conventional activated sludge system has lower treatment efficiency compared to the IDEA treatment system, because its design capacity is 20mg/L while the design capacity of the IDEA treatment system is 10mg/L. The effluent from both treatment systems had achieved standard A of the Environmental Quality Regulation 1979 (20mg/L). Comparing the operation costs for both treatment systems, the monthly operation cost for the IDEA system is RM1678 (for a system designed for 1800 population equivalent), while the conventional activated sludge wastewater treatment has the operation cost of RM1173 monthly (for 1000 population equivalent). Based on the effluent quality and operation cost, it is suggested that the IDEA treatment system is capable of higher efficiency compared to the conventional activated sludge wastewater treatment system, in terms of performance and operation cost. Maintenance works on both wastewater treatment systems would be imperative, as non-functioning components were found in both systems during the course of the study. Based on the estimated effluent flow of $180m^3$/day, as shown in [5] and [11], only 3 cycles of operation would be required per day, leading to some savings in operation and energy costs. For Resort A, analysis had shown that a smaller capacity air blower would also lead to lower costs. The cost savings of about RM136 per month leads to a total saving of RM 1632 per year, which is equivalent to the cost of a new, smaller capacity air blower.

The effluent quality of the IDEA treatment system did not meet the design capacity of the wastewater treatment systems. This suggests inadequate management of operations and maintenance of the wastewater treatment system, as non-functioning components of the equipment were not repaired or maintained. Similarly, at Resort A, the maintenance activities of the conventional activated sludge treatment system was also not managed well, as observed from equipment failure in the equalization tank that had not been neglected. On a broader perspective, the economy and policy of the government will directly affect the performance of wastewater treatment systems [19]. Furthermore, the level of environmental awareness of the residents is crucial [20].

VI. Conclusion

Performance monitoring of wastewater treatment systems is essential to evaluate the influent and effluent quality. Overall, the water quality of the influent and effluent of both wastewater treatment systems at Curtin Sarawak and Resort A had met the design aims of the respective wastewater treatment systems, except for the IDEA system where its effluent exceeded the design aim of 10mg/L of BOD_5 during peak seasons. However, the effluent quality of the IDEA system still manages to achieve standard A of Environmental Regulation 1979. Ammonia and orthophosphates levels are found to be quite high in the effluent for both treatment systems.

Based on the design assumption where $1m^3$ of wastewater requires $1m^3$ of oxygen in the aeration tank and equalization tank, and a wastewater inflow of $180m^3$/day, analysis shows that only three cycles of operation are required for the same effluent quality. A saving of 3% in operation costs will be made with three cycles of operation, as the system is operating with 4 cycles at the time of the study. As for the conventional activated sludge wastewater treatment system used in Resort A, a change to a smaller capacity air blower will reduce the operation cost by 12%.

In order to obtain better wastewater treatment, constant maintenance and upgrades should be done for the existing wastewater treatment systems.

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