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Performance of Prefabricated Sewage Treatment Plants at a Military Academy
(Prestasi Loji Rawatan Kumbahan Pasang Siap di Sebuah Akademi Tentera)

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ABSTRACT

This paper presents the results of performance monitoring of wastewater treatment systems installed at Universiti Pertahanan Nasional Malaysia (UPNM). UPNM is a military-based university located in Sungai Besi Camp, Kuala Lumpur, Malaysia. As the university expands, new buildings were constructed and new prefabricated sewage treatment plants (STPs) were installed. Effluent of these STPs were monitored and compared with required standards. Effluent samples were collected from three STPs for three months and tested for parameters of pH, temperature, biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammoniacal nitrogen, nitrate, and phosphorus. The results were then compared with the standard B of the Environmental Quality (Sewage) Regulations 2009. Diurnal fluctuation of the effluent quality was also studied. From the data observed, it shows that the performance of the wastewater treatment plant is good. The effluent quality also achieved the allowable standards set by the authority. Maximum diurnal fluctuation was observed for COD which fluctuated between 18 and 52 mg/L which is still lower than standard B for COD effluent limit of 200 mg/L.

Keywords: STP; wastewater; wastewater treatment plant; sewage; UPNM

ABSTRAK

Kertaskerja ini membentangkan hasil pemenatauan prestasi operasi beberapa loji rawatan airsisa yang digunapakai di Universiti Pertahanan Nasional Malaysia (UPNM). UPNM merupakan sebuah universiti berteraskan ketenteraan terletak di Kem Sungai Besi, Kuala Lumpur, Malaysia. Sejajar dengan perkembangan universiti tersebut, beberapa bangunan baru dibina dan beberapa loji rawatan kumbahan pasang siap baru (LRAS) turut dipasang. Pemantauan efluen LRAS ini dibuat dan dibandingkan dengan keperluan standard pelepasan. Pemantauan selama tiga bulan telah dibuat, dimana sampel efluen dari tiga LRAS tersebut telah diambil dengan beberapa parameter seperti pH, suhu, keperluan oksigen biokimia (BOD), keperluan oksigen kimia (COD), nitrogen ammonia, nitrat dan fosforus diuji. Keputusan ujian seterusnya dibanding dengan keperluan Standard B Peraturan-Peraturan Kualiti Alam Sekeliling (Kumbahan) 2009. Perubahan diurnal kualiti efluen juga dikaji. Data cerapan yang dibuat menunjukkan prestasi loji rawatan airsisa tersebut adalah baik. Kualiti pelepasan efluen telah mencapai standard yang ditetapkan pihak berkuasa. Diperhatikan perubahan diurnal tertinggi adalah pada parameter COD dimana ianya berubah antara 18 dan 52 mg/L.

Kata Kunci: LRAS, airsisa; loji rawatan airsisa; kumbahan, UPNM

INTRODUCTION

These days, all the processes, products, and services should be covered and tested from view the environment as the demands from society. This includes all treatment such as sewage treatment plants (STPs) (Gallego 2008). The application of wastewater treatment plants is based on the quality of raw sewage and the required treated water quality. The performance of sewage treatment plants covered all including expenses, mode of operation and maintenance, treated effluent quality, internal, external, and design factors (Razik 2007).

The majority of domestic sewage and industrial wastewater is the contribution of the increase in population and the rapid development of cities and industry. However, in general, the wastewater treatment plants in Malaysia are overburdened and underperforming resulting inadequate effluent quality and does not meet the Malaysian standard requirements (Tang & Ngu 2011).

Untreated wastewater can give bad effects towards the environment and contaminate the receiving water bodies which will adversely affect the ecosystem and public health. Indah Water Konsortium Sdn. Bhd. (IWK) is a national sewerage company responsible in managing and maintaining a modern and efficient sewerage system for all Malaysians. According to IWK, 38% of public sewage treatment plants in Malaysia are mechanical plants which run by using mechanical operation to fasten the breakdown of sewage.

Wastewater treatment process are designed to achieve improvements in the quality of the wastewater. It is important to treat wastewater to protect receiving waters and their associated aquatic ecosystems and also protect public health from the harmful effects of untreated sewage. Besides that, the treatment is to reduce the contaminants to the acceptable conditions.

Wastewater treatment is the process of converting the wastewater that is no longer necessary or appropriate for use into water that can be discharged or reused back into the environment safely. The objective of wastewater treatment plant is to maintain the human health and protect the environment from enormous various contaminants (Nidhi & Pandey 2016).

The main wastewater treatment types are preliminary treatment (removal of rags, rubbish, grit, oil, grease), primary treatment (removal of floatable materials), and secondary treatment (biological treatment to remove organic and suspended solids). For now, there is still no intention to build tertiary treatment systems in Malaysia. The focus has only been providing a basic standard of preliminary, primary, and secondary treatment (Mat et al. 2016).

The Environmental Quality (Sewage) Regulations 2009 is a regulation stated after the consultation with Environmental Quality Council. This regulation is enforced to any premises and institutions which discharge the effluent into any soil or into any inland waters of Malaysia, apart from residential and commercial development or both having equivalent population less than one hundred fifty (Pentas 2016). It indicates two standard categories for effluent discharges. Standard A and Standard B. Standard A is for discharges upstream of any raw water intake while Standard B is for discharges downstream of any raw water intake. Table 1 presents the acceptable conditions of selected parameters for new sewage treatment system from Second Schedule of Environmental Quality (Sewage) Regulations 2009.

TABLE 1. Sewage discharge of Standard A and B

Parameter	Unit	Standard	
		A	B
Temperature	°C	40	40
pH		6.0-9.0	5.5-9.0
BOD_5 @ 20 °C	mg/L	20	50
COD	mg/L	120	200
Suspended solids	mg/L	50	100
Ammoniacal nitrogen	mg/L	10.0	20.0
Nitrate nitrogen	mg/L	20.0	50.0
Phosphorous	mg/L	5.0	10.0

As the wastewater treatment plants are subjected to varieties of organic loads, changing environmental conditions and new industrial discharges, it is important to design the treatment system that produce effluent concentration which is equal or less than the required limits set by Standards. It is necessary for the treatment system to be reliable in meeting the requirements especially for reuse application (Metcalf & Eddy 2003)

Figure 1 describes the wastewater treatment plant process. The diagram shows that all the treatments are closely connected to each other and affected the overall design. Thus, the design must be able to produce a good quality of effluent that would meet the requirements of Environmental Quality Act 1974 (EQA) (Razik 2007).

Primary treatment is a physical removal process which is assumed to include the pre-treatment process: barrack, grit chamber, and equalization basin. The purpose of pre-treatment is to provide protection to the wastewater treatment plant that follows. As for primary treatment is to remove pollutants that either settle or float from wastewater. It will typically remove 60 percent of the suspended solids in raw sewage and 35 percent of the BOD_5 (Mackenzie & Davis 2013).

Secondary treatment is achieved by using biological process. It is to remove the soluble BOD_5 that escapes the primary process and to provide added removal of suspended solids. The secondary treatment process is designed to speed up these natural processes so that the breakdown of the biodegradable organic pollutants can be achieved in relatively short time periods. Secondary treatment may remove more than 85 percent of the BOD_5 and suspended solids, but it does not remove significant amounts of nitrogen, phosphorus, or heavy metals. The secondary process includes trickling filters, activated sludge process, and rotating biological contactors (Mackenzie & Davis 2013).

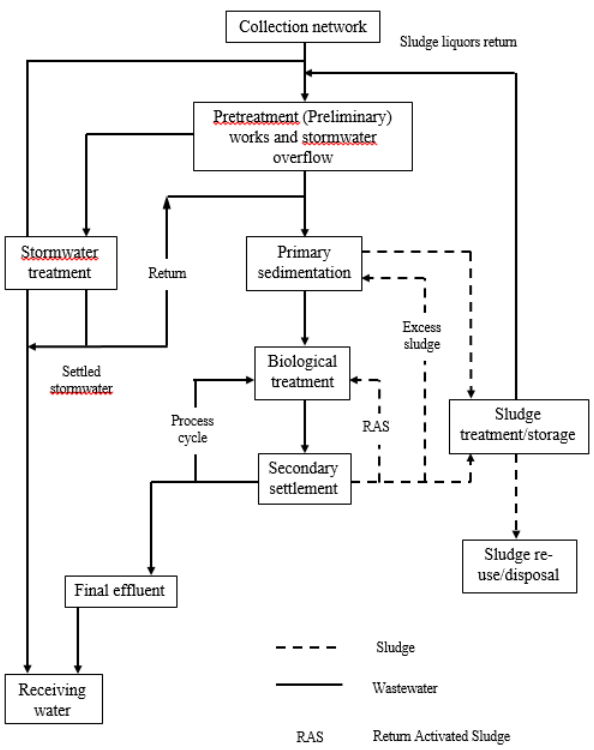

FIGURE 1. Wastewater treatment plant overview
Source: Razik (2007)

Tertiary treatment can be used to remove suspended solid and also nutrient removal process. It covers a wide range of treatment and it is a process that follows conventional secondary treatment. The BOD concentration would be very low (<10 mg/L) which provide a good basis for nitrification to occur (Mackenzie & Davis 2013)

In Malaysia, Hi-Kleen system is one of the prefabricated wastewater treatment systems use for treating wastewater. It is a high performance sewage treatment plant prefabricated by PJ Bumi Berhad for treating domestic wastewater. There are more than 50 standard models of Hi-Kleen designed to suit small and medium size of development projects. It covers the range from 65 to 5 000 of Population Equivalent (PE). These projects include residental and commercial projects, hospital, military camp, university, school, and shopping complex.

Basically, this Hi-Kleen system adopts the modified activated sludge process which uses the microorganisms in suspension to oxidize soluble and colloidal organic matters in the presence of molecular oxygen, induced by air compressors. It is made of fibre reinforced plastic (FRP) which has the characteristics of wear-tightness, light weight, and high strength.

This Hi-Kleen system is equipped with an equalization tank and a flow control box. There are four tanks which are equalization tank, aeration tank, clarifier tank, and sludge digestion tank (Razik 2007). In order to remove the solids and inorganic materials, the incoming raw sewage first passes through a screen chamber and a grit and grease chamber. Then, it will be pumped to the equalization tank via flow control box. In equalization tank, the wastewater is mixed via air diffusers producing homogenous liquor (Tang et al. 2007).

The wastewater is pumped into the flow control box which the flow will be regulated into the aeration tank. The designed hydraulic retention time (HRT) within the aeration tank is about 10 hours. The mixing is created by the turbulence induced by diffused air from air diffusers (Tang et al. 2007).

METHODOLOGY

OBJECTIVES

The main objectives of this study are:

1. To monitor the performance of the wastewater treatment plants at UPNM.
2. To determine whether the effluent achieved the standard of EQA 1974 (Sewage) 2009.
3. To check the diurnal fluctuation of effluent quality.

MATERIALS AND METHODS

Three prefabricated sewage treatment plants in operation at UPNM were selected. The first stage of the selection is to analyze the suitable wastewater treatment plants to be used. All the prefabricated STPs installed in UPNM ranging from 300 to 1 600 PE design capacity. The STP to be selected for wastewater sampling are the treatment plants that have small to medium size of plant. The three STPs selected were Main, Lembah, and PTMK STP.

Samples of effluent were collected twice a month from each STP between months of March and May 2016. Sampling was conducted between 8 to 10 a.m. The samples of treated waste water (effluent) was taken at the effluent pipe of the STPs before it is discharged into the drainage.

The collected samples were then taken to the environmental laboratory at UPNM for testing. Characteristics of the effluent were tested based on water quality parameters which are temperature, pH, five-day biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS), ammoniacal and nitrate nitrogen, and phosphorus. These laboratory tests were performed in accordance to the Standard Methods (APHA 2009). The data were then compared with the Environmental Quality (Sewage) Regulations, 2009 of Environmental Quality Act 1974 permissible limits.

24-hours monitoring were also conducted on Main STP to observe the fluctuation of effluent quality.

RESULTS AND DISCUSSION

Main sewage treatment plant treats wastewater from several buildings. This treatment plant is using extended activated sludge system. The values of the parameters may be affected because it has been in operation for more than 10 years. Figure 2 shows the performance of Main plant compared with standard B.

For Lembah, the treatment plant has approximately 1 600 PE. It covers four blocks of student's hostels. Lembah adopted the same type of treatment plant unit as Main STP which is Hi-Kleen system. Figure 3 shows the performance of the STP compared with standard B.

PTMK STP has been operating for five years. It also has the smallest population equivalent which is 300 PE. It only covers the sewage from the library and Pusat Teknologi Maklumat. Figure 4 illustrates the performance of PTMK STP compared with standard B.

Range and average values for observed effluent quality parameters are summarized in Table 3. It can be seen that that values for Main STP except for pH are the highest. This may be attributed to the fact that the Main STP has been in operation for more than 10 years. However, other factors such as higher organic and hydraulic loading and less aeration rate may also reduce the performance of the STP.

Based on Figure 2, 3, 4, and Table 2, all the parameters at each STP values are verified less than the allowable values of the standard. This shows that the performance of wastewater treatment system in UPNM are considered good and acceptable. Main STP gave the highest value among those treatment plants as it has been operating longer than the other two STPs. They represent that the effluent is acceptable to be discharged to the stream.

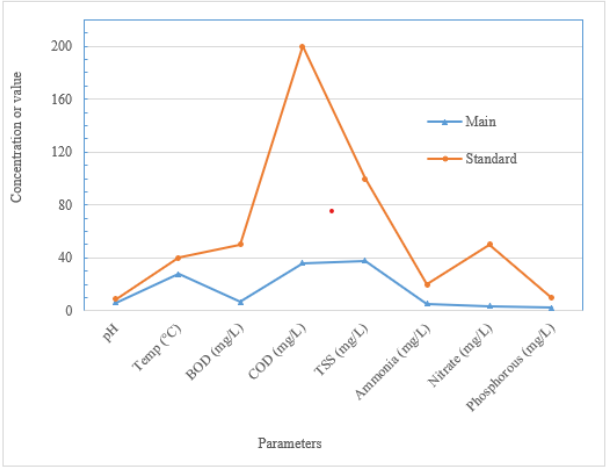

FIGURE 2. Performance of Main STP and Standard B parameters

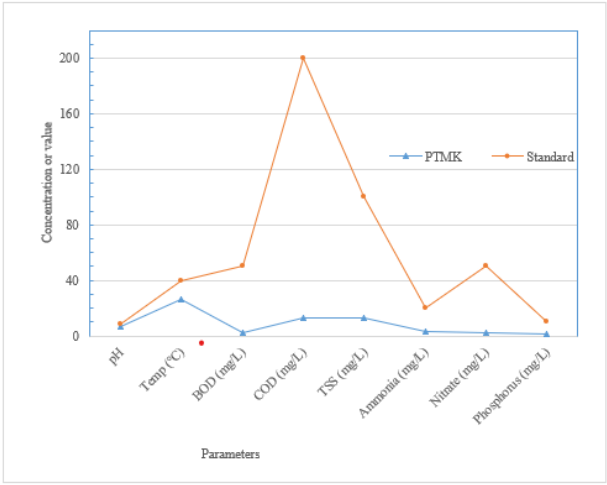

FIGURE 3. Performance of Lembah STP and Standard B parameters

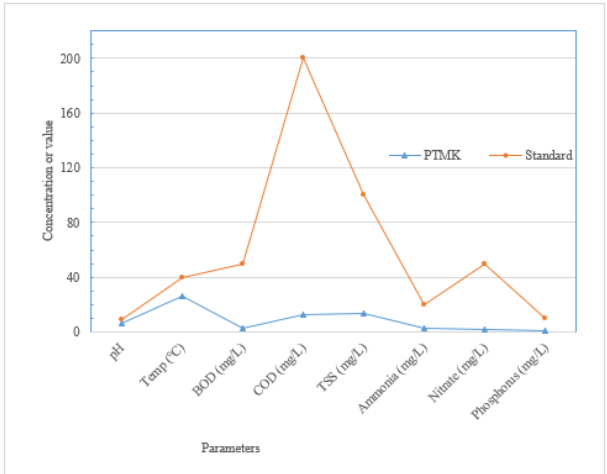

FIGURE 4. Performance of Lembah STP and Standard B parameters

TABLE 3. Summary of ranges and averages of effluent parameters

Parameter	Category	STP		
		PTMK	Lembah	Main
pH	Minimum	6.3	6.2	6.0
	Maximum	6.7	6.7	6.6
	Average	6.5	6.5	6.3
Temp (°C)	Minimum	25.8	26.3	27.2
	Maximum	27.2	27.8	28.6
	Average	26.6	27.1	27.9
BOD	Minimum	1.5	3.0	5.7
	Maximum	3.0	5.9	7.7
	Average	2.3	4.5	6.7
COD (mg/L)	Minimum	6.8	13.0	27.0
	Maximum	21.0	28.4	54.8
	Average	13.0	21.7	36.1
NH3 (mg/L)	Minimum	2.5	3.6	4.6
	Maximum	3.9	5.6	6.7
	Average	3.1	4.9	5.6
NO3 (mg/L)	Minimum	1.4	2.6	2.5
	Maximum	2.6	4.1	5.2
	Average	2.0	3.3	3.6
P (mg/L)	Minimum	1.0	1.1	1.5
	Maximum	2.0	2.2	3.6
	Average	1.3	1.8	2.5
TSS (mg/L)	Minimum	11.4	24.1	32.0
	Maximum	15.0	28.4	45.0
	Average	13.4	26.1	37.7

Results for 24-hour monitoring are shown in Figure 5. It can be observed that the values (except for pH) started to increase after 5 p.m. and peaked at 12 midnight. After 5 p.m., students return to their rooms and start to ease and wash themselves. During this period, hydraulic and organic loading are increasing and at a high rate. After midnight, most of the students were sleeping.

From Figure 5, it can also be seen that values of TSS and COD fluctuated the most. The range of TSS was from 13 to 34 mg/L with difference of 21 mg/L and the range for COD was 18 to 52 mg/L with difference of 34 mg/L. All the observed values meet the requirement of the Standard.

CONCLUSION

Based on the results obtained from the study, it can be concluded that Main, Lembah, and PTMK STP have good performance of wastewater treatment system. From the evaluation of the effluent quality, we can find that the system is efficient and can fit for currently increasing campus size and population. The effluent quality is slightly different for each STP as they treat waste water from different buildings and sources and the loadings (hydraulics and organic) are different too. The variation of concentration of pollutant may vary significantly, due to weather, human activities and other environmental conditions.

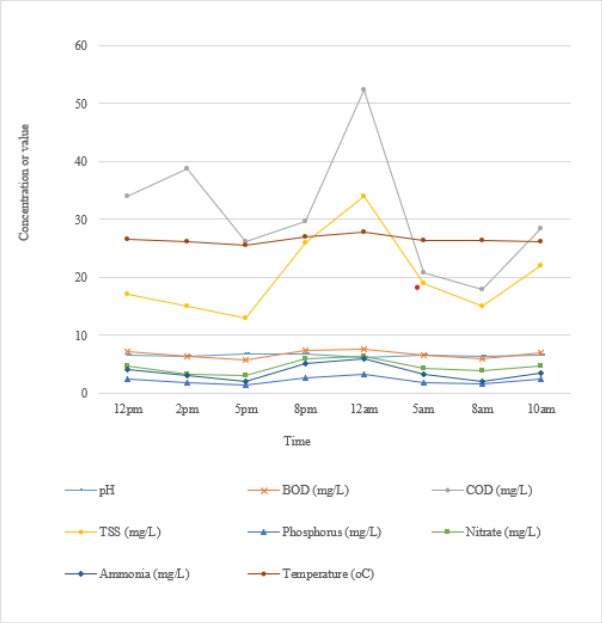

FIGURE 5. Twenty-four hours monitoring of water quality parameters for Main STP

In addition, the findings also represent that the effluent quality of wastewater from the three STP has achieve the requirements standards set by the Environmental Quality (Sewage) Regulations 2009 of the Environmental Quality Act 1974. This is significant to ensure that the receiving water are protected from unnecessary pollutant which will threaten the aquatic life and also save for recreational purposes.

DECLARATION OF COMPETING INTEREST

None

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