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Research paper

Water Quality Assessment Klang River Water Treatment Plants

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Abstract

The quality of Klang river water is deteriorating dramatically since it is in urban places every day and become one of the major problems. Therefore, the Malaysian government had initiated one river cleaning project named River of Life (ROL) project. This project is for rehabilitating and restoring the Klang river. A series of river water treatment plant (RWTP)s have been operated in Klang river catchment since 2014. Six RWTPs station has been monitored up to eight stations until presents. Eight parameters consisting of physio-chemical types and biological types have been recorded. RWTP effluent discharges are targeted to achieve Malaysia Interim National Water Quality Standard (INWQS) under Class II B. Since previous RWTP performance only emphasized on local river pollutants and certain conditions, this paper will investigate the effectiveness of full-scale RWTP unit process for river condition. Water quality assessment are involved which are consist of effluent water quality monitoring and pollutant removal efficiency. Most of the major pollutants able to be reduced by more than 50% reduction. Although BOD and AN still not able to achieve standard range gazetted by INWQS Class IIB, there is an improvement of river water quality at Klang River by using IFAS technology adopted in the RWTP system.

Keywords: *MBBR; IFAS; River; Water Quality*

1. Introduction

In the last few decades river management and restoration play an important role in the environment. Therefore, various researchers are conducted in this applied research field [1]–[3]. In the fields of research a major area is improving the water quality of the river [4], [5]. For example, the quality of Klang river water is deteriorating intensely since it is in urban places and become one of the major problems. The causes are both natural (e.g. changes in precipitation; flood; erosion;) and anthropogenic (e.g. urban, industrial and human activities) reasons for this problem. The effective way of river cleaning requires identification and quantification of both natural and anthropogenic influences and increased understanding of contaminant sources, which become a key factor for regarding planning, mitigation and cleanup processes [6]–[8].
The effective way of river cleaning requires identification and quantification of both natural and anthropogenic influences and increased understanding of contaminant sources, which become a key factor for regarding planning, mitigation and cleanup processes. The efforts to develop innovative attempts have seen be made to decontaminate rivers water directly and continuously. Therefore, the Malaysian government had initiated one river cleaning project; River of Life (ROL) project. This project is for rehabilitating and restoring the Klang river. From twelve (12) key activities have been proposed under river cleaning task force, a new technology called river water treatment plant (RWTP) had been introduced to purify the Klang river water[9]. Likely in Korea, their RWTP process is consist of gravel and artificial media which contain high surface area in contact with the surface organic substance. RWTP in Yangjae river able to remove 60% of Biochemical Oxygen Demand, 70% of Total Suspended Solid, 36% of Total Phosphorus.[10]
There are many water treatment plant technologies, either from laboratory or pilot-scale studies were known to successfully treat river water to certain degree of removal efficiency. However, continuous urban river pollution issues in Malaysia have urged more studies to be conducted to get intuition into new technologies approaches especially on RWTP. Determination of issues and problem facing by this new technology are very important besides there are no studies have been conducted to assess the effectiveness of this technologies. Plus, previous RWTP performance only emphasized on local river pollutants and certain conditions. This research work is implemented to investigate the effectiveness of unit processes combined in full-scale RWTP for Klang river condition.

2. Methodology

A series of RWTPs have been in the operation in Klang river catchment since 2014. The detailed description and location of RWTP have been described in the previous publication.[11] Fourteen (14) unit of RWTPs apply biological water treatment as similar has been incorporated Integrated Fixed Activated Sludge System (IFAS) and Moving Bed Biological Reactor (MBBR) as mention in previous publications [12]–[15]. The approaches included preliminary treatments (mixing and grit removal tank), secondary biological treatments (oxidation tank with fixed carrier), and clarifier.
The processes involved in Klang RWTP are depicted as below and Table 1:

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Inlet structure → Mixing tanks → Grit Removal → Oxidation with alternate fixed carrier (12 units) → Clarifier → Outlet structure.
Water quality assessment consist of two types of activities:
RWTP effluent water quality monitoring
Pollutant removal efficiency

Table 1: RWTP Operation Information

Operation	± 360 days per year
Sludge Collection	Yes
Sludge Recycle	No
Design Discharge (Q_{design})	0.01 m^3/s
Hydraulic Retention Time	2 hr
Nos Oxidation Tank	8 unit in total
	4 units with carriers
Types of Biological Process	Attached growth process with fixed-carriers (IFAS)

2.1. Water Quality Monitoring

Since 2014, 6 RWTPs station has been monitored up to 8 stations until presents. 8 parameters consisting of physio-chemical types and biological types have been recorded at the inlet and outlet point each station for monitoring the performance of RWTPs as follows;
1. Dissolved Oxygen (DO)
2. pH
3. Temperature
4. Chemical Oxygen Demand (COD)
5. Biochemical Oxygen Demand (BOD) at 20°C
6. Ammonia Nitrogen (AN)
7. Total Suspended Solid (TSS)
8. Escherichia-coli (E. coli)

RWTP effluent discharges are targeted to achieve Malaysia Interim National Water Quality Standard (INWQS) under Class II B which categorized as clean and suitable for recreational purposes involving body contact. This target is initially has been set up as one of the main objectives in ROL Project. One of the RWTP has been analyzed situated at Klang River (3°11'00.1"N 101°45'37.0"E). Sampling duration is analyzed from early 2015 until middle 2017. Each effluent result is compared with INWQS Class II B limit.

2.2. Constituent Removal Efficiency

The removal efficiency for MBBR and IFAS, R (%) was determined by using the equation below:

$$R = \frac{C_o - C_t}{C_o} \times 100\% \quad (1)$$

where C_0 and C_t (mg/L) are the pollutant liquid-phase concentrations at initial and time t (day), respectively [16].Then all the results will be tabulated, and graph or charts were built. All charts were developed using Microsoft Excel except for Removal Efficiency using Statistical Package Social Science (SPSS) programme version 11.0.

3. Result and Discussion

The results obtained from data collected from the monthly grab sampling at Klang RWTP. Water quality monitoring at the effluent point and pollutant removal efficiency for each RWTP station will be discussed.

3.1. Effluent Water Quality

Effluent monitoring for every pollutant is plotted as shown in Fig 1 to Fig 8.

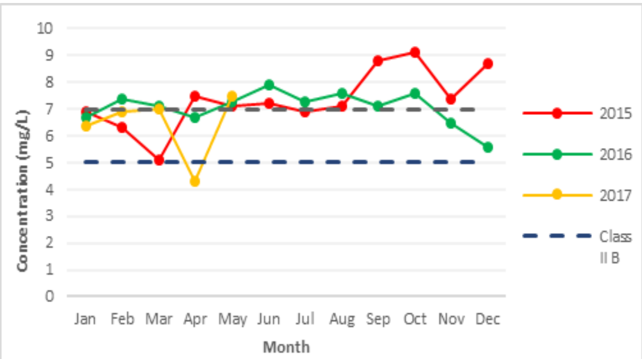

Fig. 1: Trend in DO data at RWTP outlet point from Jan 2015 to May 2016

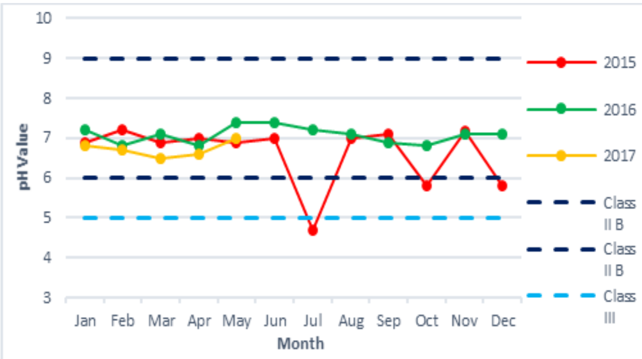

Fig. 2: Trend in pH data at RWTP outlet point from Jan 2015 to May 2016

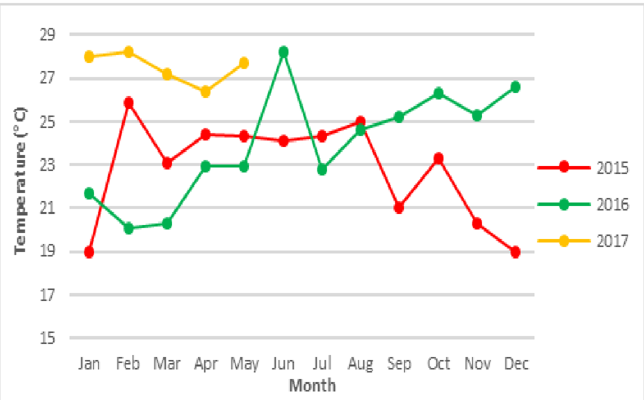

Fig. 3: Trend in temperature at Klang river RWTP outlet point from Jan 2015 to May 2016

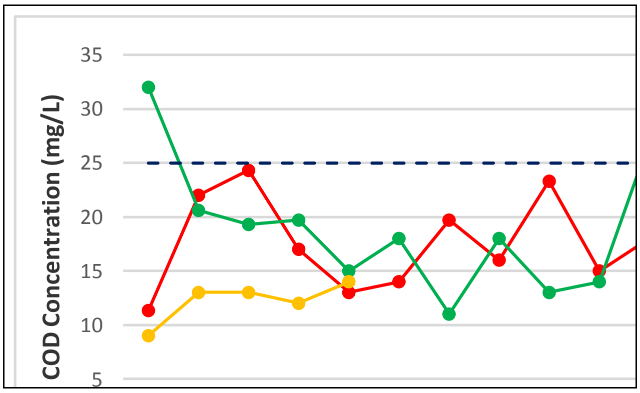

Fig. 4: Trend in COD at Klang river RWTP outlet point from Jan 2015 to May 2016

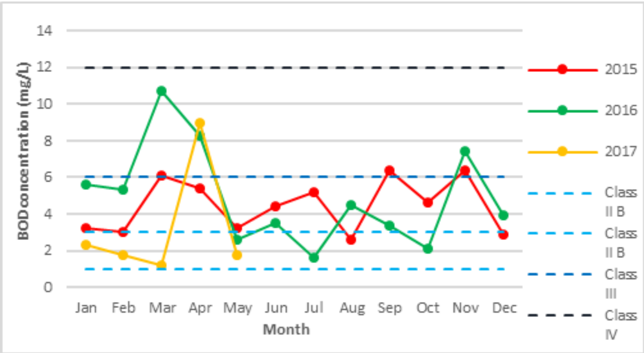

Fig. 5: Trend in BOD at Klang river RWTP outlet point from Jan 2015 to May 2016

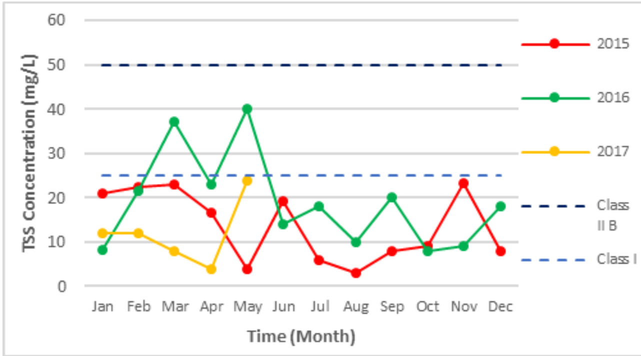

Fig. 6: Trend in TSS at Klang river RWTP outlet point from Jan 2015 to May 2016

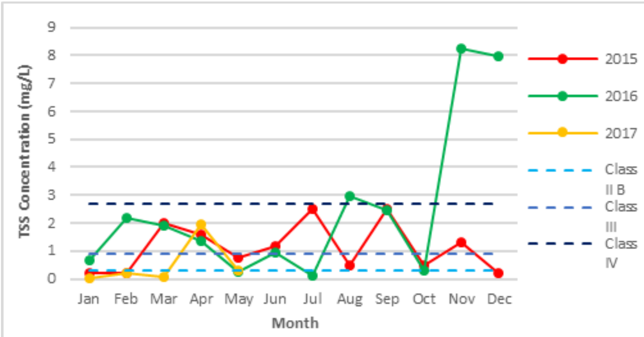

Fig. 7: Trend in AN at Klang river RWTP outlet point from Jan 2015 to May 2016

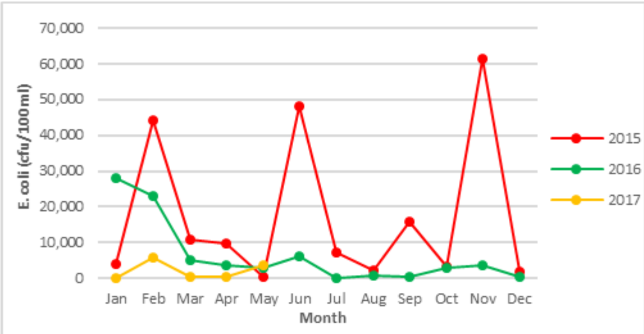

Fig. 8: Trend in E. coli at Klang river RWTP outlet point from Jan 2015 to May 2016

Malaysia experienced hot season and received a low amount of rainfall from the month of March to May. This matter could be resulting Klang river water level is decreasing and tends to reduce DO concentration as have seen in the Mar-2015 and Apr-2017 trends in Fig. 1. However, most of the DO level is more than 4.00 mg/L due to enough supply from the aeration process in the RWTP biological tank.

pH is crucial for monitoring the purification activities in the surface water. Hydrolysis process of organic compounds by biological degradation and rate of collision of sediment aggregated process is highly dependent on pH[17]–[19].Most of the pH result at the outlet point is considerable achieve the target Class II B except for July 2015 (Class III) as shown in Fig 2.

The temperature of effluent varies from 19.0 to 28.5 °C as depicted in Fig 3. The effluent COD for most of the month is according to the standard range gazette by INWQS Class IIB (Fig 4) which is permitted to be within COD 10-205 mg/L[20]. COD can be useful in pinpointing toxic condition and presence of biological resistant substances. Besides, MBBR and IFAS system which are adopted in RWTP are proven to improve the amount of COD up to 95%[21], [22].

There are 66% of total effluents BOD are not achieved to the range published by INWQS Class IIB (Fig 5). These are due to the high concentration of organic matter which has been reported in Klang river ensuing by high amount BOD [23]. As shown in Fig 6, TSS able to be reduced by MBBR and IFAS up to Class I mainly clarifier process [24]. Most of the effluents AN are not achieved to the range gazette by INWQS Class IIB as shown in Fig 7. Most of the MBBR and IFAS with nitrification control process able to reduce the desired amount of AN and Total Nitrogen and its by-products[25]. The effluent E. coli as shown in Fig 8 shows the significant reduction trend from the year 2015 to the year 2016.

3.2. Pollutant Removal Efficiency

From the Table 1 and Fig 9, COD removal rate is mostly 55%, BOD is 62%, TSS is 67%, AN 80% and E. coli reducing the highest rate which is 95%.

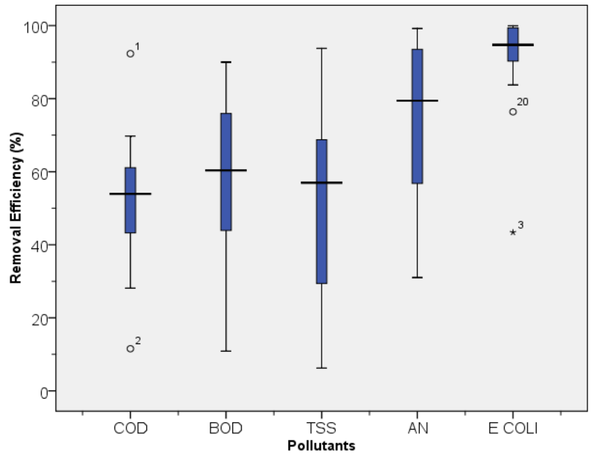

Fig. 9: Removal Efficiency for Klang RWTP

Table 1: Descriptive Analysis for Removal Efficiency

	COD	BOD	TSS	AN	E COLI
Mean	53.256	58.261	52.551	74.258	92.088
Median	55.000	61.855	56.980	79.960	95.460
Mode	31.25	25.00	66.67	31.02a	90.27a
Std. Deviation	1.544E1	2.1659E1	2.4647E1	2.0829E1	1.0785E1
Minimum	11.54	10.87	6.25	31.02	43.40
Maximum	92.31	93.55	93.75	99.21	99.97

Despite of E-Coli, RWTP Klang able to reduce tremendous amount of AN (80 ± 2.08 %) although the RWTP unit system are prior for organic substance removal. This is due to IFAS system are consider as hybrid performance which are consist of suspended and attached growth system.[26], [27]

Multiple previous studies have been conducted for nitrification process for removal AN and its group substances; Nitrite and Nitrate.[28] Nitrification process able to specific reduce ammonia content by Ammonia oxidizing bacteria (AOB) and Anaerobic Ammonium Oxidation (Annamox).[29], [30] In pilot case study, from a retrofit Sequencing Batch Reactor (SBR) to IFAS was conducted by Zhao 2018, the IFAS unit able to reduce 90% of CBOD and 96% of AN.[31]. It is proved that nitrification process are occurs in IFAS oxidation tank during shutdown of alternate aeration supply in every 30 minutes (average) for substrate utilization by Annamox bacteria. Most of the major pollutants able to be reduced by more than 50% reduction as depicted in Fig 9. Hence, there is an improvement of river water quality at Klang River by using RWTP technology.

4. Conclusion

Most of the major pollutants able to be reduced by more than 50% reduction. Although BOD and AN still not able to achieve standard range gazetted by INWQS Class IIB, there is an improvement of river water quality at Klang River by using IFAS technology adopted in the RWTP system.

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