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# Biological performance of integrated fixed film activated sludge (IFAS) process

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**Abstract.** The aim of this paper is to explore the information and analyze the performance of bio ball and spawning brush media in order to compare the findings of the performance of both biomedias by using Monod Model Equation. The integrated fixed film activated sludge (IFAS) process uses aeration and biomedias of spawning brush and bio ball which are placed fixed in the reactors 1 and 2 respectively. The duration of the study was conducted in 10 days which consist of two-phase which the first phase is monitoring water quality parameter and apply the Monod equation to obtain the performance of the biomedias as the second phase. Chemical Oxygen Demand (COD) removal of reactor 2 has a slightly higher average of 61% as compared to reactor 1 with an average of 57.50%. Thus, the COD removal is more consistent in reactor 1 compared to reactor 2. From this results concluded that IFAS system has a good performance in terms of low loading wastewater sources.

## 1. Introduction

Rivers are one of the main sources of ecosystem services for both living and non-living things. The river was utilized for both economic and social development in Malaysia which also leads to loss, degradation, and pollution of river ecosystem [1]. Water quality study of Malacca river showed that the overall water quality of Malacca river has exceeded IIB class which it has caused the death of thousand aquatic life due to the decrease of dissolved oxygen in the water [2]. Nowadays, there is much research on the method to improve the water quality for better environment [3-7]. Integrated Fixed Film Activated Sludge (IFAS) process is a relative one the technology which incorporates the use of a growth media either to be fixed or not within the suspended growth reactor. IFAS is a bioreactor setup by using a different type of biomedias and can be placed in the trickling filter of the setup or to be placed directly in the bioreactor itself [8]. Biomedias are highly effective as they are light and are easier to clean and maintain [9]. Attached biomass in the biological tank can grow on any type of surfaces such as rocks, sand, or plastic [10]. In this study, a laboratory scale of IFAS system was conducted in order to analyze the performance of the biomedias and the data obtained were based on standard river parameters and compared by using Monod equation model.



## 2 Methodology

### 2.1 Bioreactor setup

The first reactor consists of the spawning brush and the second reactor consists of the bio balls. Both reactors are filled up with 50% of the surface area covered with the biomedica. The water feed uses synthetic water and it will flow through the reactors by using a small standard size pump. The flow of the pump will be controlled and is set at a constant of 50% and 70%.

### 2.2 Material

Two types of media that will be used when conducting the lab testing. The biomedica are bio balls and spawning brush. Both biomedica takes up a volume of the concentration of 50% of the reactor.

### 2.3 Removal Efficiency of Chemical Oxygen Demand (COD)

The amount of Chemical Oxygen Demand (COD) removed in percent and the end value of effluent leaving a typical biogas digester into the environment. The influent and effluent concentrations are the two values that are entered the formula to obtain the answer of the removal efficiency.

### 2.4 Monod Model Equation

In the Monod equation,  $\mu_{\max}$  represents the specific growth rate (expressed in reciprocal hours) that is reached when all substrates are present in excess (i.e. when S becomes infinite). In practice,  $\mu_{\max}$  is approximated in batch cultures when the initial substrate concentration is much larger than the Monod constant  $K_s$  (Initial  $> K_s$ ). Monod's Model equation is used to measured microorganism growth. Where  $\mu_{\max}$  and  $K_s$  are empirical coefficients to the Monod equation.

### 2.5 Modelling Kinetic of the process

The use of mathematical and kinetic modeling in biological wastewater treatment is to estimate the performance of the reactor when is placed in similar operational conditions. For this study, the kinetic process was done in batch operation mode and varying the initial concentration of COD and monitoring its final concentration at different time intervals. The obtained data were analyzed using first order, Grau (second order), Monod, and modified Stover–Kincannon models in spreadsheet.

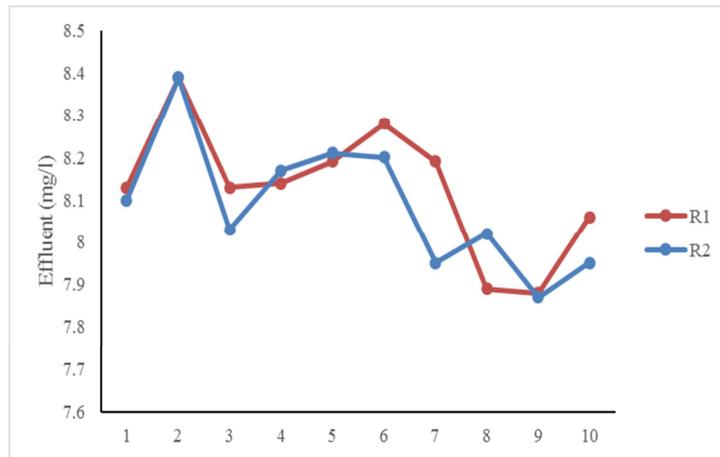
### 2.6 Biomedica removal performance analysis

The substrate removal performance of all biomedica was evaluated nine hours in a span of 4 weeks. Volumetric total substrate nitrogen conversion rate (VTR) was used as the principal indicator for evaluation of the filter media performance.

## 3 Results and Discussions

### 3.1 Dissolved Oxygen (DO)

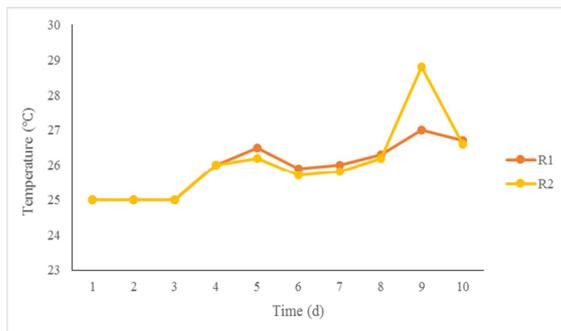
Interestingly, there only is a slight difference of DO for both reactors. It can be seen in figure 1 and value are similar to one another. Simple calculations also showed that the average DO for both reactors are 8.1 mg/l, the maximum DO to be 8.4 mg/l and minimum DO is 7.9 mg/l for both reactors as well. For this study, DO level should be more than 4 mg/l to sustain the bacteria growth in the reactor. With that being said, the results and testing are valid as it is sufficient enough to sustain the growth



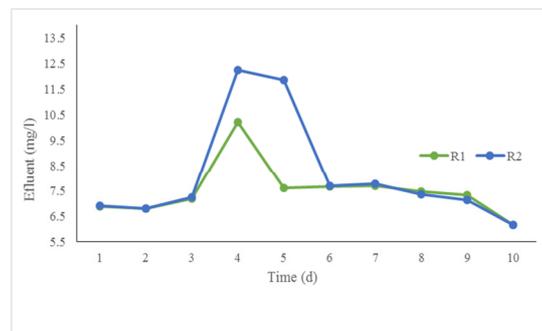
**Figure 1.** Dissolved Oxygen monitoring.

*3.2 Temperature and pH monitoring*

The DO obtained during the lab testing has an average of 8.1 mg/l. The difference is not that much and it is also important to take into consideration that the temperature for both researches is also different. The temperature of the whole process is standard room temperature with an average of about 26°C as shown in figure 2. Based on figure 3, the average pH for tank reactor 1 is 7.7 while the average for reactor 2 is slightly higher with a pH of 8.6. This indicates that the water in reactor 1 is more neutral and the water in reactor 2 is more towards alkaline. The minimum pH obtained is 6.6 for both reactors and the highest would be 12.3 for reactor 2 and 10.2 for reactor 1. This occurrence could be due to the sludge that resides at the below of the tank and affects the pH.



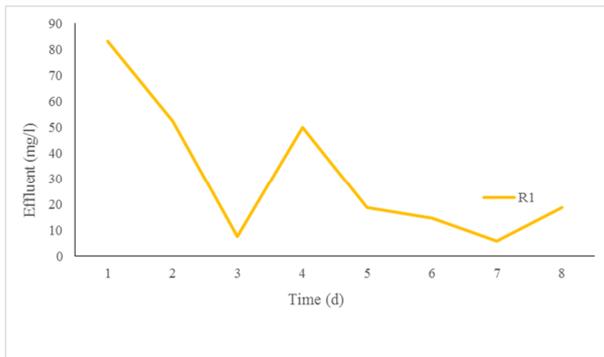
**Figure 2.** Temperature monitoring.



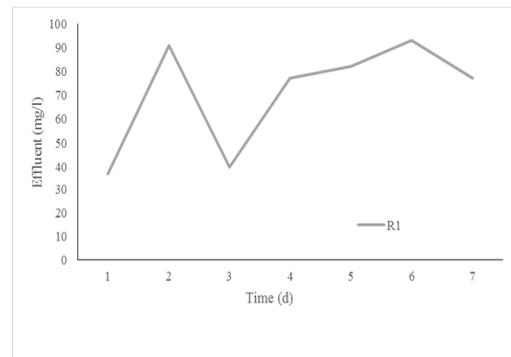
**Figure 3.** pH monitoring.

*3.3 Carbonaceous Biochemical Oxygen Demand (cBOD)*

Figure 4 shows that the initial DO and final DO for this lab testing dropped at least more than 1.0 mg/l. Though there was one day in particular that the DO did not drop more than 1.0 mg/l.



**Figure 4.** cBOD monitoring.

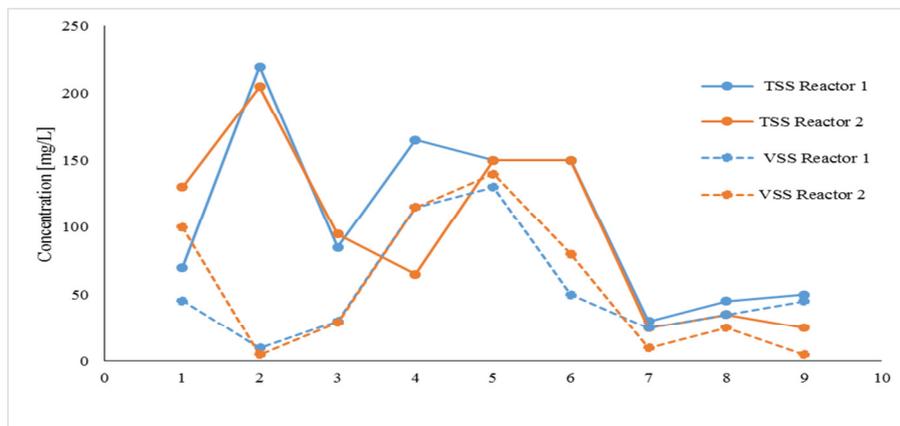


**Figure 5.** cBOD removal efficiency.

With the decrease in cBOD, it means that the oxidations of carbons are slowly decreasing. Considering that the initial cBOD is on the first day, the total number of days for the removal efficiency of cBOD is 7 days instead of 8. The cBOD removal efficiency as shown in Figure 5 is the amount of waste removed in percent.

*3.4 Mixed Liquor Suspended Solids (MLSS) and Mixed Liquor Volatile Suspended Solid (MLVSS) monitoring*

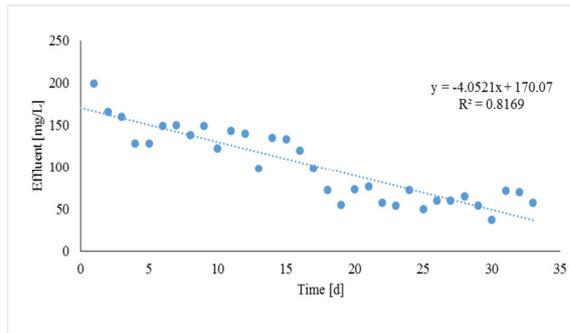
Figure 5, shows the results of the MLVSS during the testing. The results showed that the MLVSS is somewhat similar to the MLSS as during the 4th day the value of the MLVSS for both reactors shows a sudden increase as well followed by the next day. But then starts to drop on the 6th day and decreases again throughout the testing. Justifications that could be made for this occurrence would be similar to the previous justification made before for the MLSS. The increase in MLVSS would be the increase in COD removal as more microorganism is present in the aeration tank [11].



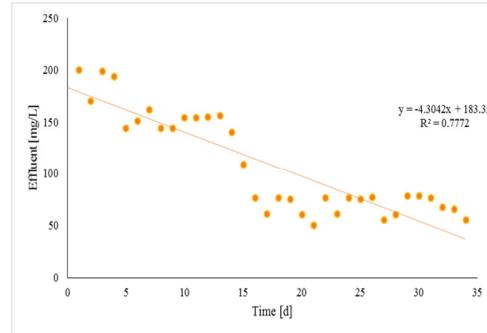
**Fig. 6.** Total Suspended Solid /Volatile Suspended Solid.

*3.5 Chemical Oxygen Demand (COS) reduction rate*

The graph results of the COD for both reactor 1 and 2 is shown in figure 7 and 8. It can be seen from the graph that it shows the COD decreases gradually in the overall testing.



**Figure 7.** COD reduction rate (reactor 1).



**Figure 8.** COD reduction rate (reactor 2).

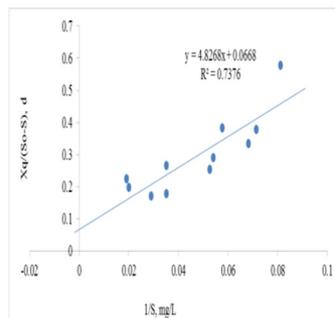
**Table 1.** Removal Efficiency rate

Type	Average	Range
R1	57.50%	32%-70%
R2	61.00%	24%-64%

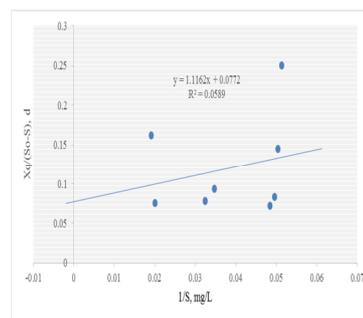
The removal efficiency indicates the performance of the ability to remove the contaminants present. The higher the removal efficiency the better. The reactor reaches its most optimum efficiency on the 7th day with a 92.99 mg/l. In terms of performance, tank reactor 2 would be more efficient as compared to tank reactor 1 as shown in table 1. COD removal efficiency reached between 83 and 92.5% and that the extended aeration process was 88 and 93.8%, where else the contact stabilization was 77 and 92% [12].

**3.6 Monod Modelling Equation**

The results for  $R^2$  for kinetic coefficient reactor 1 in figure 9 is 0.7376 and kinetic coefficient reactor 2 in figure 10 is 0.0589.  $R^2$  value for kinetic coefficient reactor 2 is lowest value and not near to 1 [13]. Therefore, relation on kinetic coefficient in reactor 2 is not sufficient and need to add another small scale value.



**Figure 9.** Kinetic coefficients reactor 1.



**Figure 10.** Kinetic coefficients reactor 2.

**4 Conclusions**

As conclusion, two different biomedias were used and has done with some investigation in terms of removal efficiency and Monod coefficient.

**Acknowledgments**

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