Effect of Hydraulic Retention Time on the Treatment of Pulp and Paper Industry Wastewater by Extended Aeration Activated Sludge System

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***Abstract*— The pulp and paper industry produce dark-colored effluent with high levels of organic matter and nutrients. As a result, a biological treatment system consisting of an aeration tank containing 3.5-6 g/L starting biomass and a clarifier chamber was set up in this investigation. After acclimation, the reactor was driven at a flow rate of 5 L/day for a few weeks at 48h, 24h, and 12h HRT. All through the investigation, the concentrations of organic and nutrient parameters are measured in the influent and effluent samples and documented for data processing. The results reveal that ammonia has satisfactorily met the Standard "A" standard limits of 10 mg/L after 24 hours of HRT. As a result, reduction efficiencies for nitrate and COD were 80.5% and 95%, respectively. Surprisingly, the majority of the effluent COD readings met the acceptable standard, so no additional testing is required. The mean BOD concentration in effluent was found to be 4.54 mg/L.**

Keywords*— *activated sludge; pulp and paper wastewater; ammonia; chemical oxygen demand; flowrate; treatment

I. INTRODUCTION

Water use in pulp and paper mills ranges from 10-100 m3 per tonne of paper made. Pulp and paper mills generate a number of contaminants as well as a significant quantity of effluent, regardless of the procedures used in the plant [1]. As the industry grows, many of them struggle to adhere to the severe environmental laws. The wastewater generated by the pulping process can be treated in a variety of ways [2]. As a result, industrial effluent limits for industrial effluents are a top concern for water quality handling schemes aimed at environmental protection. Suitable effluent limitations are required for effective control [3, 4]. The wastewater generated by the pulping process can be treated in a variety of ways [2]. According to literature [5-12], biological reactors are naturally sensitive towards the environment as they require frequent and consistent monitoring, maintenance and testing. Numerous biological wastewater treatment technologies that create less sludge have been tried [13, 14]. Scientists have recently been paying close attention to the use of an extended aeration activated sludge system (EAAS) in wastewater treatment [15]. As a result, the purpose of this study is to use bench scale EAAS to verify the influence of HRT during the treatment of pulp and paper industry effluent.

II. METHODOLOGY

These experiments are performed to obtain the characteristics of wastewater constituents [16-19]. The wastewater sample is obtained from a pulp and paper industry, located in Kedah, Malaysia. Treatment of wastewater sample is conducted using EAAS system, which is fabricated in the laboratory. The experimental setup comprises aerated influent and effluent tanks that are both connected to aeration tank [20]. The reactors were connected by peristaltic pump silicone tubing to the influent tank with 20 litres capacity. The bench- scale biological activated sludge reactor setup and schematic flow process are shown in Fig. 1. The reactor was supplied with biological feedstock although during operation stage. Influent wastewater was continually injected into the reactors at a rate of 5 litres per day. At specified intervals, influent and effluent specimens were taken, and the reactor's efficiency was regularly monitored.

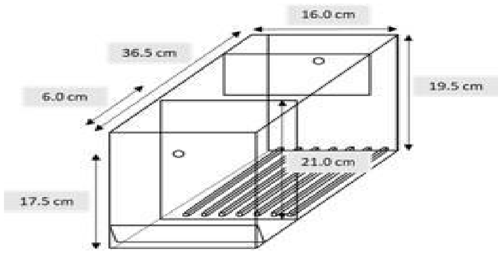

Fig. 1. Dimensions of the utilized bench scale activated sludge reactor.

III. RESULTS

In this sub-section, the study findings will be extensively detailed for each component of the study, with illustrations of the graph's behavior and the factors impacting the data collected. All plots will be divided into two phases: phase 1 (acclimatization) and phase 2 (experimentation). Phase 1 will see the graph's value gradually stabilize in order to achieve the reactor's optimal acclimatization. Phase 2 began once the reactor had been thoroughly acclimatized and was ready to be fed with the wastewater samples with various HTR's.

A. Chemical oxygen demand

COD concentrations are shown in Fig. 2 above over the duration of the investigation. The influent concentration varies between 1200 and 1400 mg/L. The difference in COD value throughout phases 1 and 2 may be plainly noted. The reactor exhibited a minimum COD of 167 mg/L from sampling day 5 to 8 during acclimation. The effluent produced after treatment has a steady COD result. The reactor has stabilized after 24 hours of HRT, and the effluent COD value hovers between 97-102 mg/L on monitoring days 31 to 35. The mean percentage of COD elimination has been calculated to be 95%.

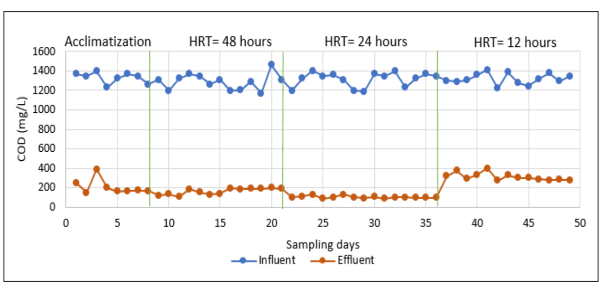

Figure 2: Graph of chemical oxygen demand

B. Ammonia

The influent ammonia concentration as presented in Fig. 3 ranged from 7-13 mg/L. While effluent ammonia decreases from 13.6 mg/L to 1.7 mg/L. From sampling day 5 to day 8, effluent ammonia concentration does not vary too much which shows that ammonia reading has stabilized with average effluent concentration of 3.0 mg/L. Throughout the acclimatization of reactor, the average reading of ammonia concentration in the influent is 6.5 mg/L and 1.7 mg/L for the effluent. From sampling day 9 until sampling day 19, the average reading of influent ammonia concentration is 8.0 mg/L with peak reading of 9 mg/L on day 12. While effluent ammonia reading experienced a steady increase with a peak of 3.7 mg/L on day 21. However, from day 23 onwards, ammonia concentration experiences a slight drop to 2.5 mg/L on day 24. 84.7% ammonia removal efficiency was achieved.

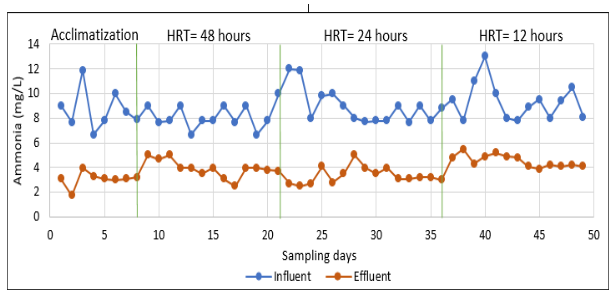

Figure 3: Graph of ammonia concentrations at different HRT

C. Nitrate

Fig. 4 depicts the nitrate concentration over the course of the investigation. During sampling days 1 to 8, influent nitrate levels were found to be quite low, averaging 1.6 mg/L on average, with a peak of 10.0 mg/L on day 4. The effluent content was determined to be excessive, with an average reading of 36 mg/L. This is because nitrification was happening in the activated sludge system [21]. Nitrate was not removed in the activated sludge system because nitrate can only be removed in anoxic condition, which is not present in this system [22]. After feeding the reactor with pulp wastewater effluent, nitrate was observed to be lower than acclimatization of reactor [23]. Effluent nitrate should be high due to nitrification where ammonia is being degraded to nitrate [24]. In aerobic condition, there should not be any nitrate removal. It is assumed that there may be chemicals constituents in the pulp wastewater acquired that enhance the removal of nitrate in the reactor.

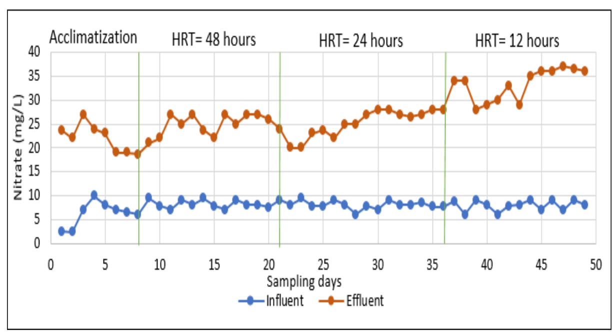

Figure 4: Graph of nitrate concentrations at different HRT

D. Phosphate

Fig. 5 depicts the phosphate content during the research. For acclimation, the reactor was fed 20 L of residential wastewater from sample day 1 to sampling day 8. The influent and effluent phosphate concentrations average 64.5 mg/L and 12 mg/L respectively. On the second sampling day, the influent phosphate concentration had increased by 5%, from 64.5 mg/L to 70.1 mg/L. From sampling day 15 on, wastewater was taken from tank two, resulting in higher in effluent phosphate readings, with a high of 25 mg/L on day 39 and an average reading of 15 mg/L.

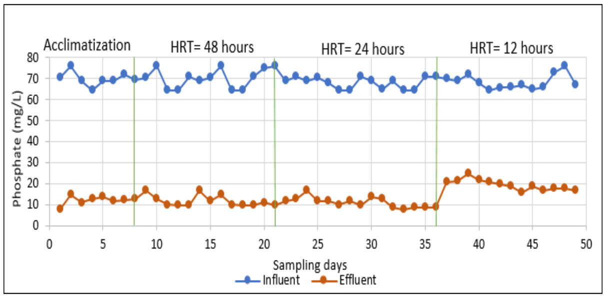

Figure 5: Graph of phosphate concentrations at different HRT

E. MLSS/MLVSS

MLSS and MLVSS in the aeration tank is heavily controlled to maintain the value above 6000 mg/L as per requirement of activated sludge system for industrial wastewater. As shown in Figure 6, the reactor started at almost 9000 mg/L of MLSS value and steadily declining after excess sludge have been removed from the reactor. When the value of the MLSS float around 6000 mg/L for 3 days which occur around sampling day 7 to day 9, this show that the reactor has stabilized and ready to be fed with the industry wastewater. On sampling day 10, which is the first day of sampling day of new mix of influent, the value of MLSS is around 5000 mg/L and increasing steadily until sampling day 15. This may be due to the amount of food for bacteria is high in the industry wastewater sample. On sampling day 16 to day 18, the value keeps rising which resulted in increasing of volume of sludge need to be removed to ensure the stability of the reactor. Sampling day 19 until 24 is the result of the sludge removal which allow the reactor to stabilize again and keep the value of MLSS around 3500-4000mg/L. Based on the graph above, it shows that domestic wastewater used have low volatile suspended solids which explain the steady number of MLVSS ranging from 1600-2000 mg/L even if the MLSS is high. For the pulp industry wastewater, based on sampling days 10 to day 24 throughout, the value of MLVSS were almost 75% of MLSS.

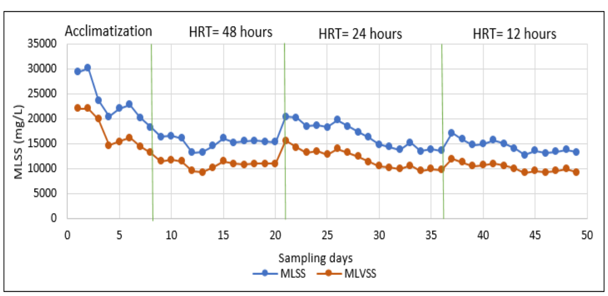

Figure 6: Graph of MLSS and MLVSS at different HRT

IV. CONCLUSION

The research investigated the effect of hydraulic retention time in an activated sludge reactor contaminants removal from pulping industry wastewater. The reactor efficiency was assessed through the removal rates of phosphorus, nitrate, ammonia, and COD. It could also be evaluated by monitoring the MLSS and MLVSS values at every sampling day. The aerobic EAAS system first undergoes the primary acclimatization stage for biomass stabilization, and then the treatment of domestic wastewater with several 20% concentration of the industrial wastewater. The F/M ratio were able to identify at the average of 0.98 and the sludge age of the reactor after being fed with industrial pulp wastewater is range between 79 days to 192 days. 86.13% ammonia was removed. In the case of phosphorus, 89.47% removal rate was attained. Consequently, nitrate and COD removal efficiencies were 80.5% and 95% respectively. Remarkably, the majority of effluent COD values met the required standard, so no more testing was required. The average BOD concentration in effluent was found to be 4.54 mg/L.

ACKNOWLEDGMENT

Authors would like to acknowledge the support received by the staff and management of the Department of Civil & Environmental Engineering, Universiti Teknologi PETRONAS, Bandar Seri Iskandar, Perak Darul Ridzuan Malaysia

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