UMTAS 2013
Advancements in Marine and Freshwater Sciences

Preliminary Study on Up-flow Anaerobic Sludge Blanket (UASB) and Down-flow Aerobic Filter (DFAF) Two Phase Combined Reactor Systems in Treating Domestic Wastewater

Mohd Afindy B. Abd Kadir[1,*], Ab. Aziz B. Abdul Latiff[1] and Zawawi B. Daud[1]

[1]*Department of Water & Environmental Engineering, University Tun Hussein Onn Malaysia, Parit Raja, 86400 Batu Pahat, Johor, Malaysia*
**Email: afindykadir@gmail.com*

Abstract

Anaerobic wastewater treatment technology has shown high potential in organic removals as well as cost-effective processes. This paper presents an evaluation of the feasibility of employing UASB reactor followed by DFAF treating domestic wastewater. Besides, the performance of using zeolite and coconut shell activated carbon as support material will also be appraised. The microbial communities that are responsible for pollutant and nutrient removal are identified. An analytical study is carried out to evaluate the performance of combined UASB and DFAF reactors in a sequence operation. A 6.36 L UASB reactor seeded with sludge from anaerobic pond at University Tun Hussein Onn's sewerage treatment plant is fed with domestic wastewater taken from the same treatment plant. The effluent of UASB directly discharged into the DFAF which has 2.84 L capacity. The DFAF is a down-flow filter through pack of zeolite and coconut shell activated carbon respectively. Aeration is provided via oxidation during filtration. The wastewater is fed continuously with increasing OLR until the reactor failed. The domestic wastewater samples are analyzed for pH and COD. The findings of this study would hopefully contribute to the enhancement of current established system in treating domestic wastewater.

Introduction

Since pure water is limited source throughout the world along with rapid increase a population in urban areas gives reason for concern and need a proper water management practices. As a result of the expansion of industry sectors, more organic contaminants are discharged which are usually associated with the municipal wastewater. This is due to the wide use of chemicals in households e.g. pharmaceuticals, personal care products, detergents and disinfectants.

According to the standard criteria of water quality, municipal wastewater contains considerable amount of contaminating organics, elevated concentrations of nutrient e.g. nitrogen, phosphorus, and sulfur compounds, which would lead to environmental pollution crisis if discharged without appropriate treatment. Municipal wastewater is characterized as low to medium pollutant level effluent with respect to the important parameters in (mg per l) e.g. COD of 500, BOD of 300, TN of 43, TP of 20, oil and grease of 20, and TSS of 450 (Sanz & Fdz-Polanco, 1990; Sandeep, 2008). For all intents and purposes, anaerobic wastewater treatment has been introduced as a clean technology due to its feasibility of high to low strength wastewater digestion, with lowest amount of sludge production compared to the other systems (Banu et al, 2007). In particular, UASB bioreactor has successfully recorded high organic (COD) removal efficiencies as well as stable operation system (Lettinga & Hulshoff, 1991). Furthermore, this system is considered as an attractive treatment technology due to its economical operation compared to such treatment as aerobic technology (Lew et al, 2004; Najafpour et al, 2009).

However, aeration process is considered as predominant factor that is required for nutrient removal, with the interference of specific bacteria which can be created in aerobic and anaerobic systems (Noophan et al, 2009). Moreover, nitrogen compounds are extremely in need of oxidation and carbon source as electron donor in order to loose the elemental nitrogen, which can be performed within series of reactions known as nitrification and dinitrification. On the other hand, phosphorus and sulfur compounds are required in adsorption process, which can be achieved within an additional filtration system that packing with high adsorbent surface materials (Abulbasher M. Shahalam, 2009).

This research concentrates on the effect of combination reactor UASB and a hybrid UASB-filter reactor with DFAF reactor for domestic wastewater treatment, at different of media, organic loading rates (OLR) and hydraulic rentation time (HRT).

Materials and Methods

The domestic wastewater used in this study was collected from a municipal sewerage wastewater treatment plant located in UTHM campus, Batu Pahat, Johor, Malaysia. The wastewater was collected, filtered and stored at 4°C before feeding to the treatment system. The wastewater is classified as a medium strength (Metcalf and eddy, 1991). The wastewater was modified increase COD to 1000 mg/l COD concentration by addition of Glucose, peptone and meat extract. To prevent pH fluctuation of the influent, $NaHCO_3$ and K_2HPO_4 were added to wastewater (Hossein Hazrati et al). The influent wastewater characteristic of wastewater is present in table 1.

Table 1: Influent Characteristic

Parameter/Composition	Concentration
Chemical Oxygen Demand (COD)	1000 mg/l
Ammonia Nitrogen, NH_3-N (AN)	45 mg/l
Total Phosphate (TP)	21 mg/l
pH	4-5.5
Suspended Solid (SS)	61 mg/l
Colour	271 NTU
Oil & Grease	7 mg/l

Combination of two laboratory scale reactor Up-Flow Anaerobic Sludge blanket (UASB) with Down-Flow Aerobic filter (DFAF) are use in the experiment. Three UASB reactors R1,R2 and R3 were fabricated to give a working load volume of 6.36 L (9.0 cm diameter, 100 cm high), with six sampling ports placed at different heights. The hybrid UASB reactors were packed with suitable size media around 5-10 mm zeolite for R2 and coconut shell activated carbon for R3 with size ranged 2-3mm, respectively. The top of each reactor is fixed with GSS (gas-solids Separators) to prevent biomass wash out. The DFAF reactors with volume 2.84 L is labelled as S1, S2 and S3.

Characteristic of the inoculums

The inoculums used to start the granules of sludge are obtained from sewerage treatment plant located in UTHM campus. The inoculum is deposited in the UASB reactors to act as seed sludge in the formation of microbial granules. The volume of biomass 2.36 L and kept at temperature at 26±3^{0}C.

Procedure for reactor acclimatization

Once the inoculums was added to each reactor the modified municipal sewerage wastewater (influent) was fed via the peristaltic master-flex pump system into the UASB reactor, then the effluent from UASB was channelled toward to DFAF reactor by tubes. Three perspex laboratory-scale UASB reactor; R1, R2, and R3 were operated together. Basically, a low OLR is recommended for the first start up operation, this provides a good acclimatization of sludge bed elements.

Experimental procedure

Experiment is performed in two parts. The first part, the feed flow rate OLR was regulated at 0.45 kgCOD.m^{-3}.day^{-1}. While the hydraulic retention time of 2.21 days were maintained during the reactor start-up operation for the first steady-state. The long HRT was used in order to provide a good development of microorganisms as well as to prevent the sludge washout phenomenon. The achievement of steady state period can be determined through the 90 % COD removal. The OLR and HRT were estimated according to the Equation **(a)** and **(b)**

$$\mathbf{OLR}\ (\mathbf{kg\ COD.m^{-3}.day^{-1}}) = \frac{\text{COD influent (kg.m}^{-3}) \times \text{Flowrate (m}^3\text{.day}^{-1})}{\text{Volume of reactor (m}^3)} \qquad \text{(a)}$$

$$\mathbf{HRT}\ (\mathbf{Day}) = \frac{\text{Volume of reactor (m}^3)}{\text{Flowrate (m}^3\text{.day}^{-1})} \qquad \text{(b)}$$

The effluent characteristics were statistically analyzed in term of average, minimum and max values. In the second part, effluent from the upper level of UASB was allowed to continue to the DFAF reactor to determine the performance of DFAF in term of nutrient removal. A long term of operation was implemented in a continuous operation until steady state achieved. The arrangement of the UASB-DFAF system is shown in figure 1.

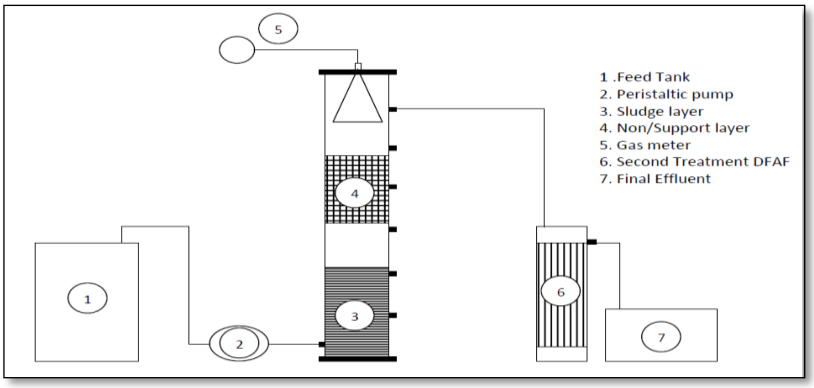

Figure 1: UASB-DFAF R1 and HUASB-DFAF R2&R3 treatment system

Results and Discussion

Chemical Oxygen Demand (COD)

At the earlier start-up stage, COD removal for R1, R2 and R3 were already high since the beginning of treatment, the percentages and values of COD removal for R1, R2, R3 shown in Figure 2 and Figure 3 while percentages and value of COD removal for S1, S2, S3 shown respectively in Figure 4 and Figure 5. The percentages of removal are in the range of 80-90%. Initially, the reactors were continuously fed with OLR of 0.45 kg COD/m^3/d and flow rate of 2 ml/min. For R1, the reactor reached steady state at the 12th day as since that day the COD removal keep increasing until constant readings were recorded. For R2 and R3 the steady state period started at the 16th and 14th respectively and removal increased until the reading become constants. Basically, the high COD removal in R2 and R3 has shown the effectiveness of media as an absorbent material in both reactors.

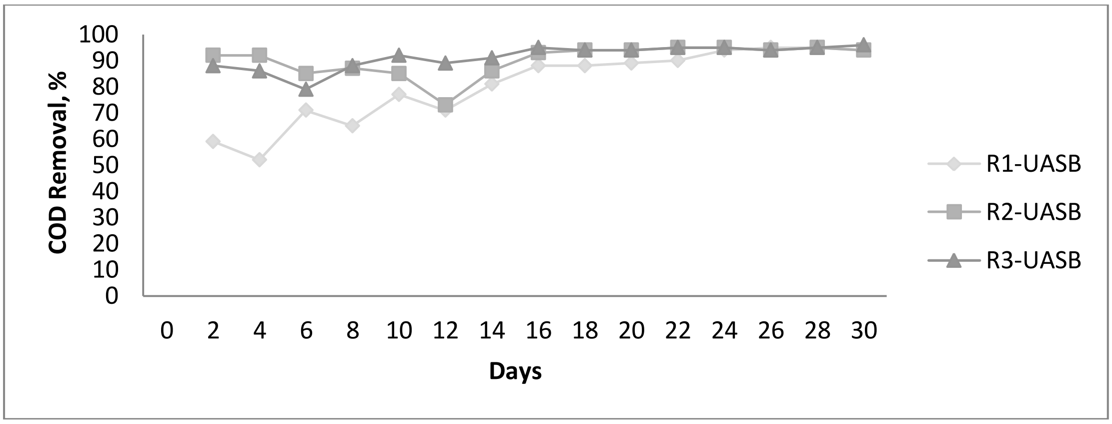

Figure 2: Percentage of COD removal in from R1, R2 and R3

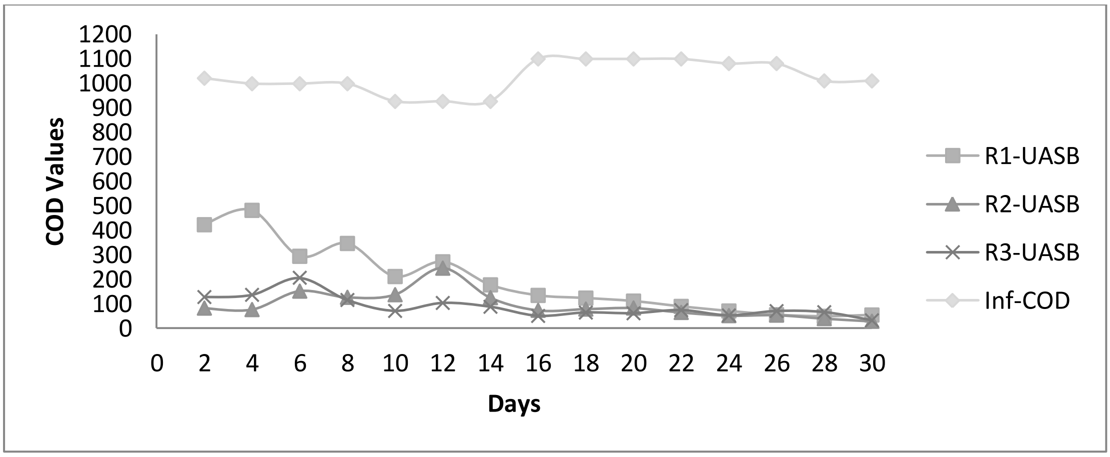

Figure 3: COD values in R1, R2 and R3

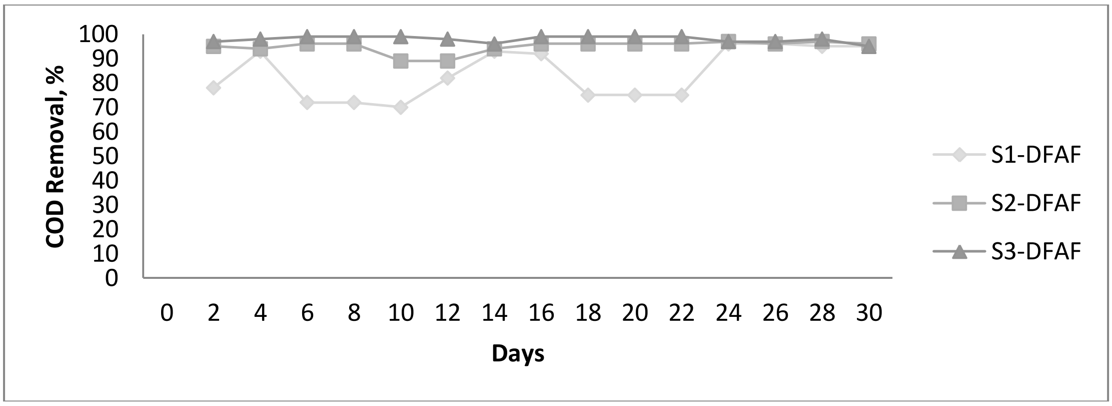

Figure 4: Percentage of COD removal in from S1, S2 and S3

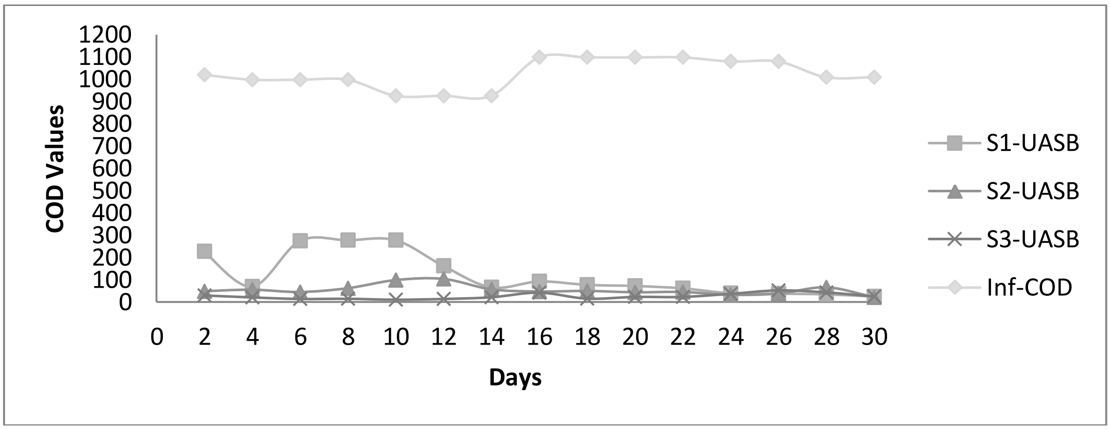

Figure 5: COD values in S1, S2 and S3

pH change in reactors

The pH ranges of the influent and effluent of municipal sewerage wastewater are shown in figure 6 and figure 7. The influent range was around 4-5.5 and effluent value of pH start from day 1, pH in R1, R2 & R3 was increased and maintained in the range 6.0-6.8 for UASB reactor, but in DFAF reactor the range of pH value were 6.0-8.0. It can be concluded the pH value is around the neutral value 7.0.

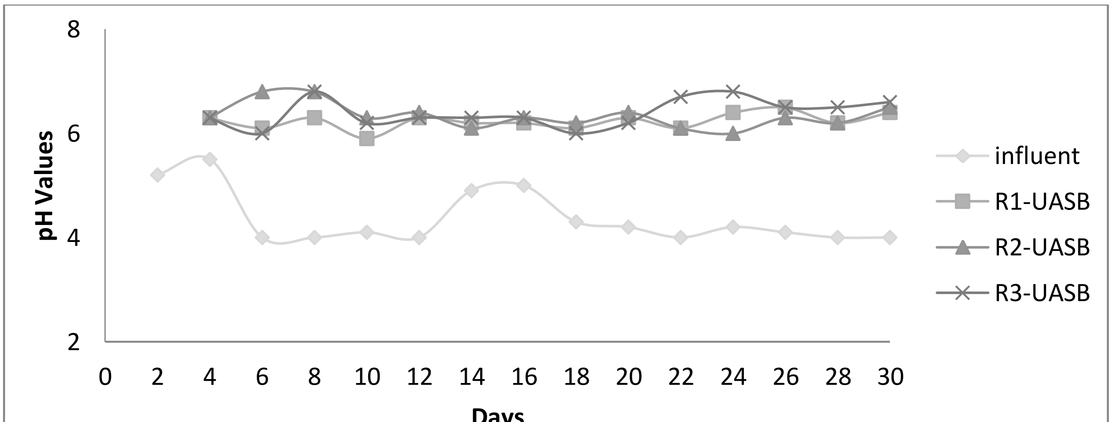

Figure 6: pH values in R1, R2 and R3

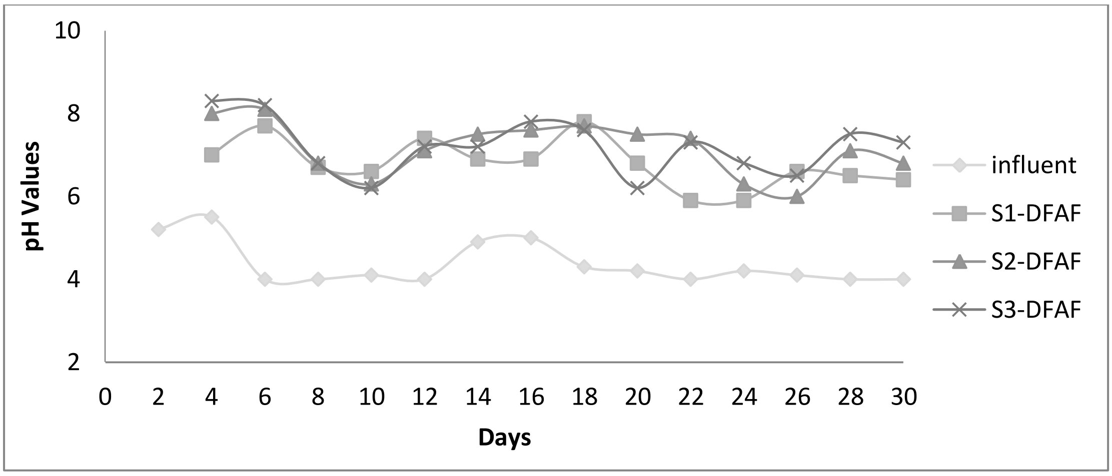

Figure 7: pH value in S1, S2 and S3

Conclusion

In view of the prospects of the expected outcomes of this project, it can be hypothesised that the system introduced would enhance the removal efficiencies of the treatment thus contributed to the achivement of clean technology and improving the efficiency of UASB by the addition of DFAF in the treatment of domestic wastewater. This can be of high significant in economic services sectors as well as in the protection of the environment. This finding could be applied in other sectors of municipal sewerage wastewater treatment plants to be contributed in clean and green environment.

Acknowledgements

The authors would like to thank University Tun Hussein Onn Malaysia for the Opportunities and the financial support from Ministry of Education for FRGS Grant Vot 1071.

References

APHA (American Public Health Association), 1998, Standard Methods for Examination of Water and Wastewater 20th ed. APHA Washington, DC, USA.

Banu, J. R., Kaliappan, S., Yeom, I. T., (2007). Treatment of domestic wastewater using upflow anaerobic sludge blanket reactor. Int. J. Environ. Sci. Tech. 4(3): 363-370.

Hossein Hazrati, Jalal Shayegan. Optimizing OLR and HRT in a UASB Reactor for Pretreating High- Strength Municipal Wastewater

Lettinga, G., & Hulshoff, Pol., (1991). UASB-process design for various types of wastewater. Wat.Sci. Tech. 24(8): 87-107.

Lew, B., Tarre, S., Belavski, M., Green, M., (2004). UASB reactor for domestic wastewater treatment at low temperatures: a comparison between a classical UASB and hybrid UASB-filter reactor. Water Science and Technology. 49(11–12): 295–301.

Noophan, P., Paopuree, P., Kanlayaras, K., Sanya, K., Techkarnjanaruk, S., (2009). Nitrogen Removal Efficiency at Centralized Domestic Wastewater Treatment Plants in Bangkok, Thailand, EnvironmentAsia, 2: 30-35.

Sanz, I., Fdz-Polanco, F., (1990), Low temperature treatment of municipal sewage in anaerobic fluidized bed reactors, Water Research, 24(4): 463-469.