Journal of Engineering and Technology

TREATMENT DOMESTIC WASTEWATER USING UASB AND DFAF TWO PHASE COMBINED REACTOR SYSTEMS: PRELIMINARY STUDY

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ABSTRACT

Anaerobic wastewater treatment technology has shown high organic removals as well as cost-effective processes. This paper presents an evaluation of the feasibility of employing Up-flow Anaerobic Sludge Blanket (UASB) reactor followed by Down-flow Aerobic Filter (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 of nutrient removal were identified. An analytical study carried out to evaluate the performance of combined UASB (R1, R2, and R3) and DFAF (S1, S2, and S3) reactors in sequence operation. 6.36 L UASB reactor seeded with sludge from domestic sewerage plant anaerobic pond to be fed with domestic wastewater. The effluent of UASB reactor was directly discharged to the DFAF reactor of 2.84 L capacity. The DFAF is a down-flow filter through pack of zeolite and coconut shell activated carbon respectively. The wastewater was fed continuously with increasing Organic Loading Rates (OLR) until the reactor failed. Parameters measured were pH and Chemical Oxygen Demand (COD). The instruments used for collecting data in this research were pH meter and COD analyzer. In this research, the highest COD removal of the effluents from the R1, R2 and R3 were on the 12th day with 95% removal, 16th day with 96% and 14th day with 95% removal respectively. Meanwhile, in the post-treatment system, the highest COD removal of the effluents from the S1, S2 and S3 were on the 4th day with 85% removal, 6th day with 70% removal and 6th day with 93% removal. These findings of the study would contribute to the enhancement of current established system in treating domestic wastewater.

KEYWORDS: *Domestic wastewater; two phase combined reactor system; coconut shell activated carbon.*

1.0 INTRODUCTION

Water is one of the most valuable natural resources in the world. Unfortunately, it is being rapidly contaminated and urgent measures need to be taken to avoid its deterioration. In many countries, wastewater is released directly to lakes and rivers without treatment, and environmentally and economically feasible methods for wastewater treatment, are therefore, urgently needed as mentioned by Larisa Korsak (2008). Most communities

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generate wastewater from both residential and non-residential sources. Residential wastewater is a combination of excreta, flush water and all types of wastewater generated from every room in a house. It is more commonly known as sewage and is much diluted. There are two types of domestic sewage: black-water or wastewater from toilets, and gray water, which is wastewater from all sources except toilets. Black-water and gray-water have different characteristics, but both contain pollutants and disease-causing agents (Ofoefule et al., 2004).

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 of effluent with respect to the important parameters in (mg/l) e.g. COD of 500, Biological Oxygen Demand (BOD) of 300, Total Nitrate (TN) of 43, Total Phoshate (TP) of 20, Oil and Grease of 20, and Total Suspended Solid (TSS) of 450 (Sanz & Fdz-Polanco 1990). 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 onsidered as an effective reatment technology due to its economical operation compared to such treatment as aerobic technology (Lew et al., 2004).

However, aeration process is considered as the predominant factor which required for nutrient removal, with the interference of specific bacteria that 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 packed with high adsorbent surface materials (Abulbasher, 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, OLR and Hydraulic Retetion Time (HRT).

2.0 MATERIALS AND METHODS

The domestic wastewater used in this study was collected from a municipal sewerage wastewater treatment plant located in Universiti Tun Hussein Onn (UTHM) campus, Batu Pahat, Johor, Malaysia. The wastewater was collected, filtered and stored at 4°C before feeding the treatment system. The wastewater was classified as a medium strength (Metcalf & Eddy, 2003). The wastewater was modified by increasing COD concentration to 1000 mg/l in addition to Glucose, peptone and meat extract. The influent characteristic of wastewater are as presented in Table 1.

Table 1. Influent Characteristics

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 UASB blanket with DFAF were used 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 2-3 mm, respectively. The top of each reactor was fixed with GSS (gas-solids separators) to prevent biomass from washing out wash out. The DFAF reactors with volume 2.84 L was labelled as S1, S2 and S3.

2.1 Characteristic of the inoculums

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

2.2 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 channeled 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.

2.3 Experimental procedure

The experiment was performed in two parts. In the first part, the rate of OLR feed flow 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% of COD removal. The OLR and HRT were estimated according to the Equation (1) and (2).

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

$$HRT\ (Day) = \frac{Volume\ of\ reactor\ (m^3)}{Flowrate\ (m^3.day^{-1})} \quad (2)$$

The effluent's characteristics were statistically analyzed in term of average, minimum and maximum 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 continuously steady state was achieved. The arrangement of the UASB-DFAF system is shown in Figure 1.

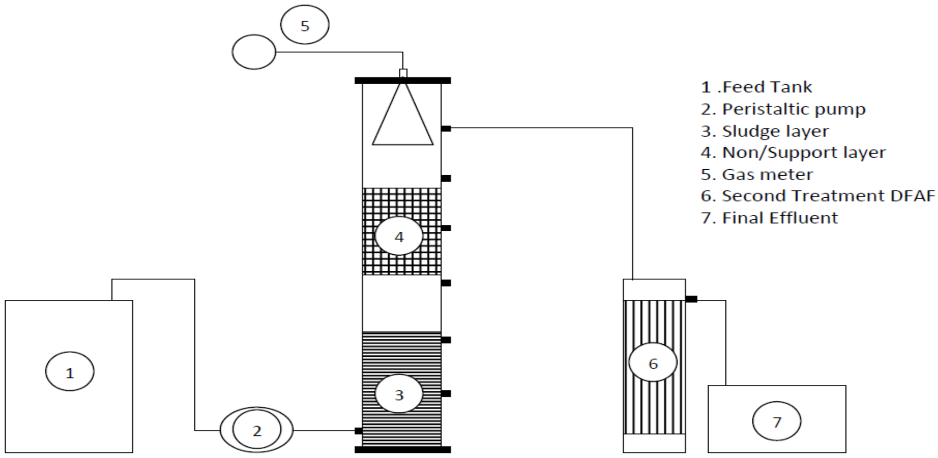

Figure 1. UASB-DFAF R1, HUASB-DFAF R2 and R3 treatment system

3.0 RESULTS AND DISCUSSION

3.1 Chemical oxygen demand

In 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 were 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 were in the range between 90% to 95%. 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 on the 12th day as since that day the COD removal keep increasing until constant readings were recorded. While the steady state period for R2 and R3 started on the 16th and 14th day respectively. The removal continually increased until the reading become constant. Basically, the high COD removal in R2 and R3 has shown the effectiveness of media as an absorbent material in both reactors. Meanwhile, in post treatment DFAF patent of removal based on UASB effluent shown in Figure 5, 6 and 7 with percentages removal 70% to 90%.

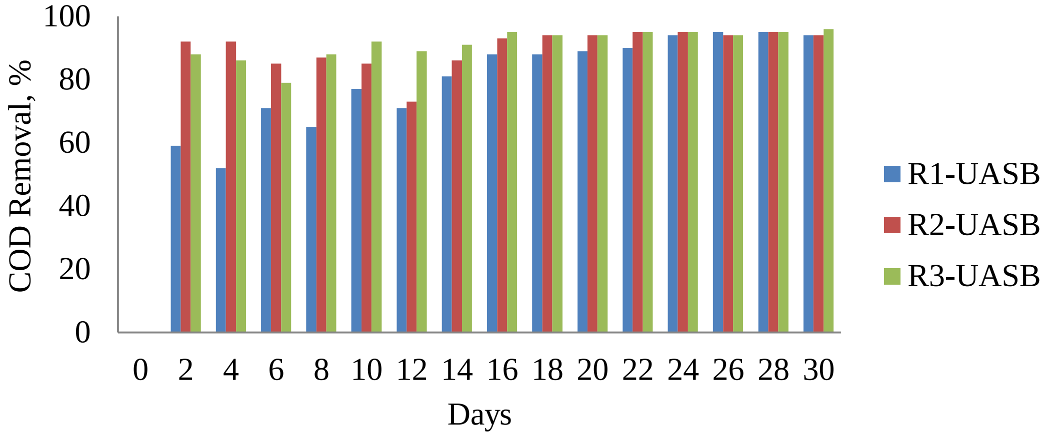

Figure 2. Percentage of COD removal in from R1, R2 and R3

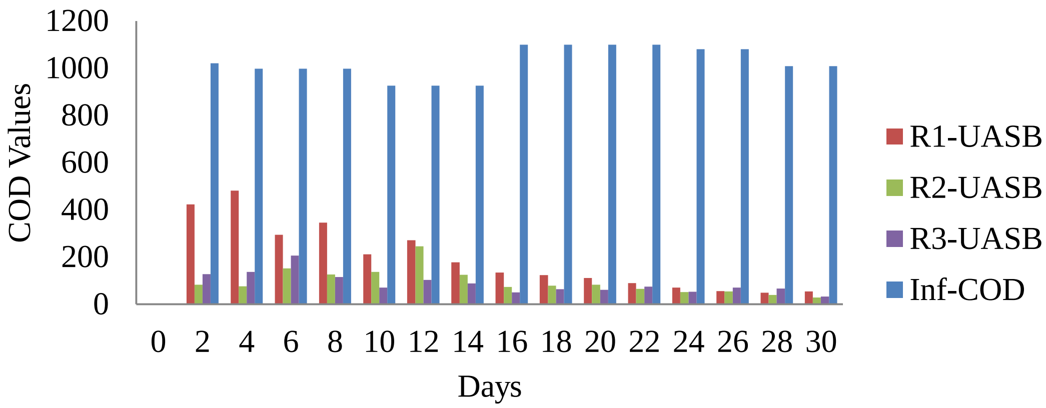

Figure 3. COD values in R1, R2 and R3

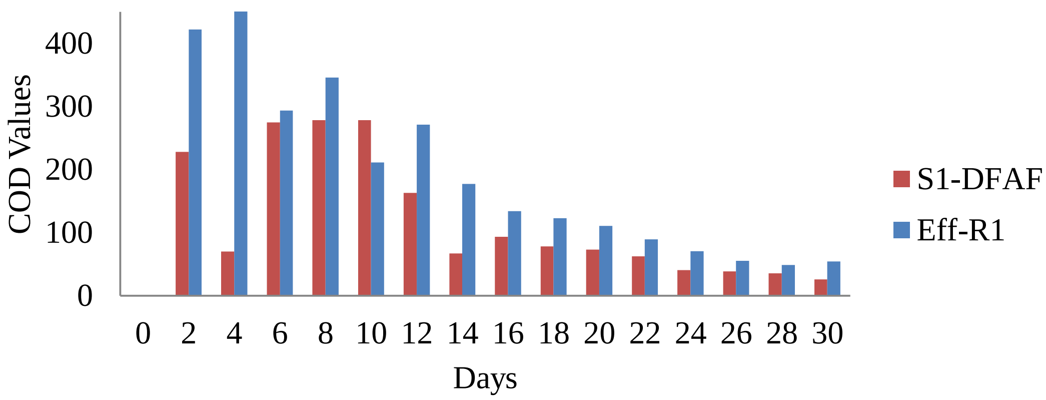

Figure 4. COD values in S1

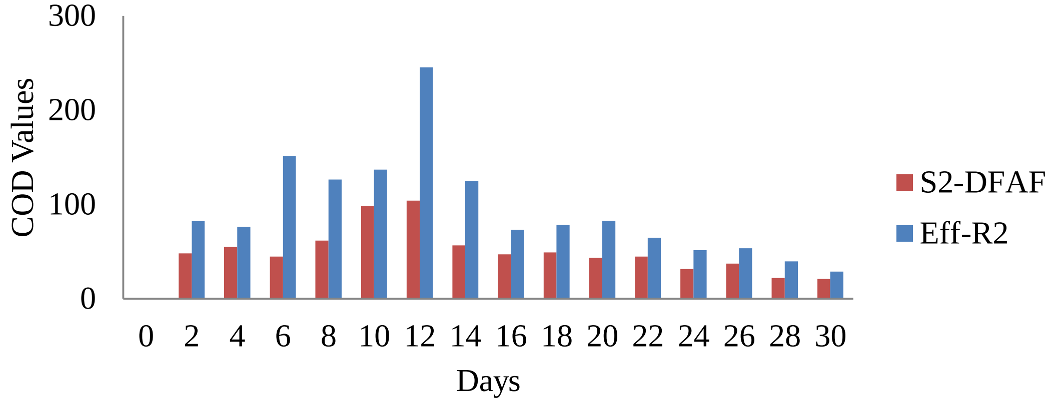

Figure 5. COD values in S2

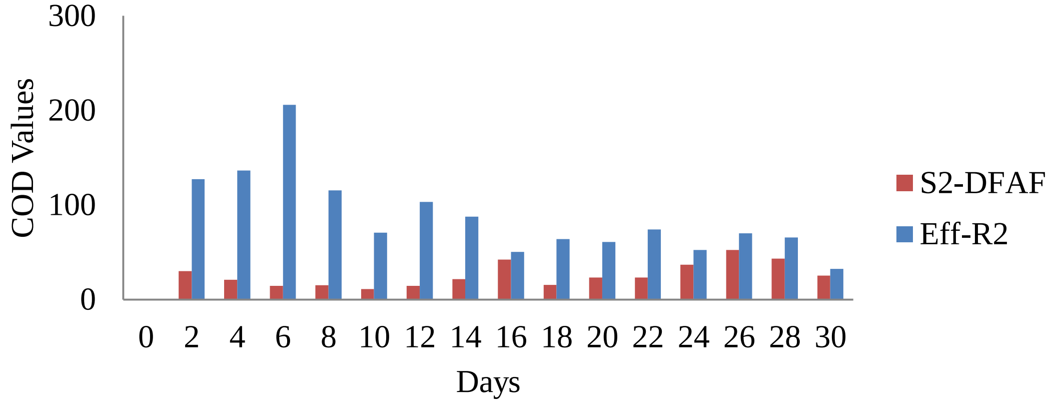

Figure 6. COD values in S3

3.2 pH change in reactors

The pH ranges of the influent and effluent of municipal sewerage wastewater are shown in Figure 7 and Figure 8. pH value of the influent was recorded around 4 to 5.5. Meanwhile, pH value of the effluent in R1, R2 & R3 has increased and maintained since Day 1, between 6.0 to 6.8 in UASB reactor, but 6.0 to 8.0 in DFAF reactor.

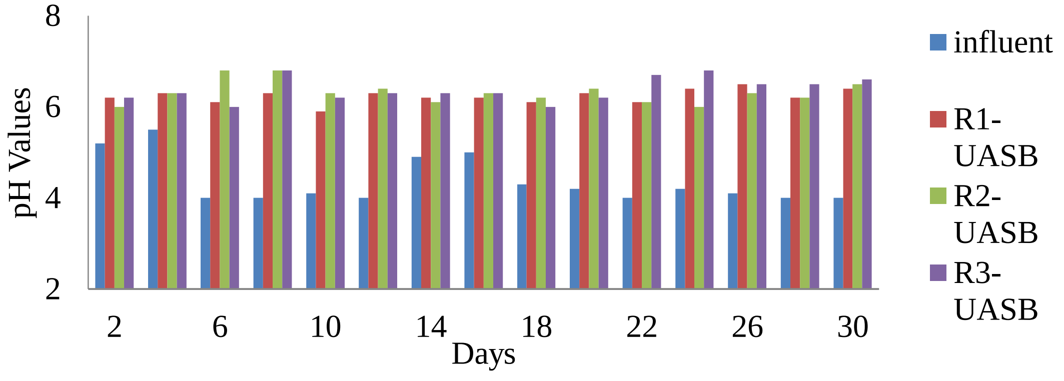

Figure 7. pH values in R1, R2 and R3

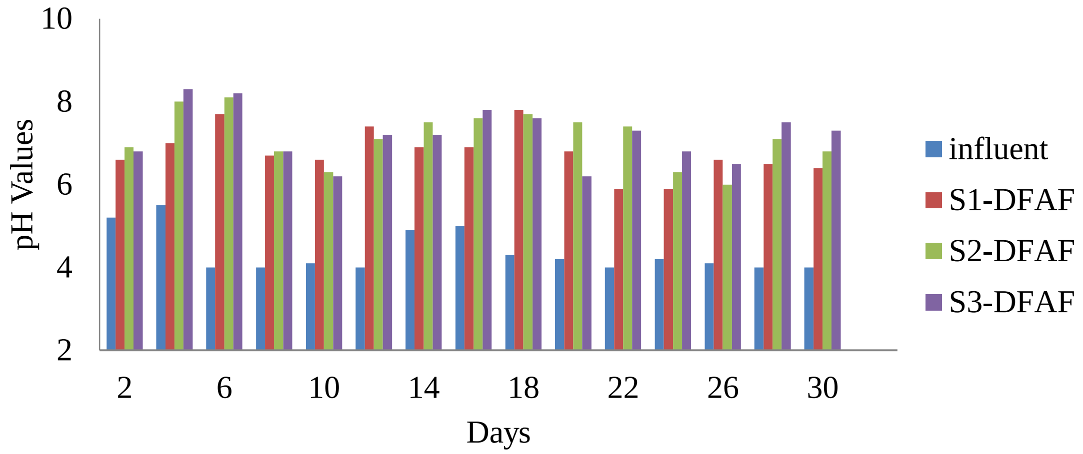

Figure 8. pH value in S1, S2 and S3

4.0 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 contributing 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.

ACKNOWLEDGEMENT

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.

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