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Effect of organic loading rate (OLR) on the performance of modified anaerobic baffled reactor (MABR) supported by slanted baffles

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ABSTRACT

The performance of a modified anaerobic baffled reactor (MABR) treating synthetic wastewater at different organic loading rates (OLRs) was investigated. The MABR was seeded with anaerobic sludge taken from a local municipal wastewater treatment plant and fed continuously with glucose at OLRs of 0.258, 0.787 and 2.471 kgCOD/m^3·d at hydraulic retention time (HRT) of 4 d. Results showed that 99.7% chemical oxygen demand (COD) removal was achieved during the OLR of 0.258 kg COD/m^3·d. However, when the OLR was increased to 0.787 kgCOD/m^3·d, a minor decrease in the COD removal efficiency (95%) was noted. Further increase of the OLR to 2.471 kgCOD/m^3·d caused the reactor performance to deteriorate dramatically in a COD removal efficiency of 39.5%. Biogas yield was evaluated for the reactor system and followed the similar decreasing trend (0.542, 0.524 and 0.214 L/g $COD_{removed}$ for the different OLRs respectively). There were no significant different in the pH profiles (6.71–7.01) during the first two OLRs (0.258 and 0.787 kgCOD/m^3·d). However, during the final OLR (2.471 kg COD/m^3·d) the pH profile in MABR significantly dropped as low as 4.01. A similar trend was also observed in the volatile fatty acids (VFAs) profile where higher value (2880 mg/l) was found at the highest OLR. The poor performance of the MABR at high OLR signifies that the microorganisms could not metabolise the organic substance and probably need more time for digestion.

Keywords: Modified anaerobic baffled reactor; Organic loading rate; Synthetic wastewater; Biogas yield; Hydraulic retention time

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1. Introduction

Wastewater treatment engineering nowadays focuses on fulfilling these requirements; a) uncomplicated design, b) minimal construction and maintenance cost, and c) superior treatment success [1]. Successful application of anaerobic technology for the treatment of industrial wastewaters is critically dependent on the development and the use of high rate anaerobic bioreactors. Among the high-rate anaerobic reactors, the anaerobic baffled reactor (ABR) can be considered as one of the most convenient anaerobic treatment systems. Apart of treating domestic wastewater, ABRs were extensively used in the treatment of recalcitrant wastewater such as palm oil mill effluent, swine wastes, pulp and paper mill black liquors, azo dyes containing wastewater, landfill leachate, synthetic tannery wastewater containing sulfate and chromium (III), whisky distillery wastewater, nitrogen containing wastewaters, textile dye wastewater, and brewery wastewater [2].

High rate anaerobic biological reactors may be classified into three broad groups according to the mechanism used to achieve biomass detention which are, fixed film, suspended growth and hybrid system [3]. The ABR was initially developed by McCarty and co-workers at Stanford University [4]. Then the process of ABR was used and described by Bachman et al. [5,6] with strong synthetic wastewater. The ABR can be described as a series of up-flow anaerobic sludge blanket (UASB) but requires no particular granule formation for its operation. This is done by the narrow down-flow and the wide up-flow inside each compartment of the ABR [7]. Series of vertical baffles forces the wastewater to flow under and around them as it passes from an inlet to outlet. Bacteria within the reactor gently rise and settle due to flow characteristics and gas production in each of its compartment. Some bacteria move horizontally down the reactor at a relatively slow rate. Its design ensures contact of biomass with substrates without the need to use any mechanical mixing. Wastewater can come into intimate contact with a large amount of active biomass as it passes through ABR while the effluent remains relatively free of biological solids. This configuration result in high chemical oxygen demand (COD) removal. ABR is significantly able to separate acidogenesis and methanogenesis longitudinally down the reactor, allowing different bacterial groups to develop under most favourable conditions [8]. The reactor is better than other bioreactors in terms of long sludge retention time (SRT), good confrontation to organic shock loading, its unique capability to separate phases of anaerobic microbial activity, retention of biomass without media or a solid-settling chamber, and also extremely stable to hydraulic shock loading [3,9].

Despite the uniqueness of the ABR, this apparatus also encountered a few drawbacks, namely, sludge washout and feeding stress in the first compartment. Both problems caused a reduction in ABR efficiency. There are several prior arts relating to the improvement of the ABR to solve this problem. For instance, Jun et al. [10] disclosed an anaerobic baffling internal circulation reactor. The reactor comprises a solid and liquid separation chamber, a baffle, air outlets, sludge outlets, a water inlet, and water outlet and three-phase separators. The baffle divides the reactor into two partition chambers wherein the first partition chamber comprises an internal circulation system; the upper part of the second partition chamber comprises a secondary three-phase separator and water outlet; the top of the second partition chamber consists of a secondary air outlet; and the lower part of the second partition chamber consists of sludge outlets. The volume of the first partition chamber is greater than that of the second partition chamber. With the configuration of this reactor, high strength wastewater can be treated, the running stability can be controlled, and air stripping internal circulation stirring and mixing system is introduced. Feng et al. [11] disclosed an ABR developed to increase biomass retention. The reactor comprises of six compartments wherein the six up-comer regions were filled with hollow-sphere carriers made of bamboo in settled form. The bamboo carriers allowed biomass retention in attached form and had the ability to entrap suspended solids from domestic sewage. Zhu et al. [12] disclosed an anaerobic baffled reactor with four compartments wherein each compartment was further separated into two parts by 45° slanted edge baffles. For the purpose of controlling the water level and trapping solids, a sedimentation tank with a volume of 1.5 L was attached to the last compartment. Although the prior art has disclosed a variety of ABR, the solid washouts from the compartments and feed stress problem in the first compartment have not been resolved. Therefore, there is still a need to improve such configurations. One of the objectives of the MABR, in this study, is to provide an apparatus for wastewater treatment to improve control on solid washout.

Many studies have been reported in the literature on anaerobic digestion using glucose as the substrate. Doaa et al. [13] studied the stability and the performance of an ABR operating on glucose-based synthetic wastewater and found that the optimum OLR for start-up was 1.8 kgCOD/m^3·d. The start-up performance of an innovative multi-stage anaerobic reactor (a modification of ABR) using glucose at various OLRs was investigated by Alkarimiah et al. [14]. The reactor was operated at a hydraulic retention time (HRT) of 1 day corresponded to an OLR of 1.07 kgCOD/m^3·d. The performance of an ABR during start-up period was studied by Bassuney et al. [15] using synthetic wastewater containing glucose and their results showed that an OLR of 1.8 kgCOD/m^3·d was the best. A comparison of the start-up performances for in the upflow anaerobic sludge blanket (UASB), hybrid, and baffled reactors was performed by Hutňan et al. [16], using glucose as a substrate. Organic loading rate was increased gradually from an initial value of 0.5 to 15 kgCOD/m^3·d in all the reactors. In another study by Mousavi et al. [17], an ABR was fed with Phenol as primary substrate and glucose as co-substrate during the investigation of Phenol biodegradation. Farrokhi et al. [18] investigated the biodegradation of mono Chlorophenol by ABR with a mixture of 3-MCP and glucose as synthetic wastewater. Decolorization and biological degradation of Azo Dye Reactive Red 2 by ABR combining with aerobic reactor were studied by Naimabadi et al. [19]. A synthetic wastewater containing glucose was used during the start-up phase before adding Azo Dye Reactive. The influence of the OLRs on the performance of a periodic anaerobic baffled reactor (PABR) was examined by Stamatelatou et al. [20] using glucose. The above review of literature clearly shows that glucose has been used as a synthetic wastewater for various operations of the ABR.

In the current study, we have modified the ABR reactor with the inclusion of several baffles in each compartment of the reactor system. The modified anaerobic baffled reactor (MABR) is an enhancement of the existing ABR where each compartment was further divided by slanted baffles. In reactor operation, an increment of the OLR is one of the major causes that initiate deterioration in the anaerobic degradation process; which is primarily due to the sensitivity of the anaerobic microorganism to the excess organic loads. Therefore, this study aims to observe the effect of different OLR to the MABR system. The MABR is deemed novel since none of the prior art disclosed an anaerobic baffled reactor having slanted three-phase separator in each compartment.

2. Materials and methods

2.1. Modified anaerobic baffled reactor (MABR)

The MABR was a rectangular box consists of four identical Plexiglas compartments with a total working volume of 28 L (4 compartments, each of 7 L). The operational set-up, the flow diagram and the reactor design are presented in Fig. 1. Each compartment was further divided by slanted (45°) baffles, and within each compartment down-comer and up-comer regions were created. The passage of liquid from one compartment to another was through an opening measuring 10 mm × 50 mm located about 23 mm from the top of each compartment. The outlet of MABR was connected to a plastic U-tube to control the level of wastewater and to trap the solids. Gas production was monitored separately for each compartment using an optical gas-bubble counter having a measurement range of 0–1.5 l/h and precision within ± 1%. Each compartment was installed with a heater, and the temperature was maintained at 37 ± 0.5°C. A digital temperature probe located in each compartment provided the constant operation temperature. Peristaltic pump (Longer Pump BT100-2J) was used to control the influent flow rate.

2.2. Seed sludge and substrate

The reactor was seeded with anaerobically digested sewage sludge (Bunus Sewage Treatment Plant, Kuala Lumpur). 12 L of sieved sludge (using 2.0 mm mesh) was added equally to each compartment (3 L in each compartment), the remaining volume being filled with tap water. This amount of sludge contributed substantially to the solid requirement in the reactor system after settling. The sieved sludge contains total solids (TS) of 30100 mg/l and total volatile solids (TVS) of 9525 mg/l. After seeding, the head plates were attached, and the headspace above each compartment was flushed with nitrogen gas to displace residual air in the system before introducing the feed. The reactor was allowed to stabilize at 37°C for seven days without further modification.

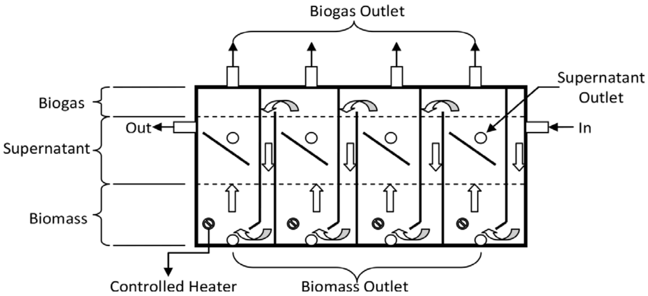

Fig. 1. Design and flow diagram of MABR system.

As for the substrate, glucose was used in this study because of its degradation simplicity and high COD value. Glucose is a soluble carbohydrate that is readily degradable, and it will not limit itself from anaerobic biodegradation rate. It generates simply measurable intermediary metabolites in anaerobic digestion and is widely used in experimental studies as carbonaceous substrate. The ratio to correct macronutrient deficiency was selected as COD: N:P = 250:5:1 [21]. The nutrient deficiency was corrected by using macronutrients N100 (Table 1). The alkalinity was maintained in all reactor compartments at 1000–2000 mg/l as $CaCO_3$ by using sodium hydroxide (NaOH).

2.3. Reactor operation

This study was carried out after the MABR was started successfully and operated for the HRT studies [22]. In the previous study [22], the start-up of the reactor was suc-

Table 2
Composition of macronutrient N100

Parameter	Concentration
Crude protein	(min) 5%
Crude fat	(min) 2%
Crude fibre	(max) 8%
N.free extract	45%
Calcium	2%
Phosphorus	1%
Magnesium	0.50%
Sulfur	2%
Potassium	2%
Salt	2%
Iron	0.08%
Iodine	0.03%
Boron	0.018%
Cobalt	0.0008%
Copper	0.0005%
Fluorine	0.015%
Riboflavin	8.00 mg
Manganese	0.09%
Molybdenum	0.0012%
Selenium	0.00002%
Zinc	0.005%
Vitamin A	50,000 IU
Vitamin D	3,000 IU
Vitamin E	150 IU
Vitamin K	1.00 mg
Vitamin B12	0.04 mg
Ascorbic acid	1500.00 mg
Biotin	0.30 mg
Choline	50.00 mg
Folic acid	0.30 mg
Niacin	25.00 mg
Panthothenic acid	0.20 mg
Thiamin	3.00 mg

cessfully accomplished for 82 d. The MABR was set to a constant HRT of 4 d after optimization of the HRT, and the effluents were recycled as feed by the ratio of 2:1 (effluents flow:feed flow). For this study, three different OLRs were tested where each of the OLR was operated for four feeding cycles. Only the last three cycles' samples, for each OLR, were then collected and analyzed. The first feed cycle sampling was neglected due to the adaptation of the microorganism inside the MABR to the new organic loading rate. The study was conducted for 48 d, 16 d for each OLR after the reactor approached steady state. Table 2 shows the reactor operational conditions during the treatment process.

2.4. Sampling and analysis

Supernatant liquor, gas and sludge samples were taken separately for each compartment. In addition, gas production rate was determined separately for each stage using an optical bubble counter. Sample analysis included chemical oxygen demand (COD), pH, alkalinity, volatile acids (VA), suspended solids (SS), and volatile suspended solids (VSS). The measurement of SS and VSS was adapted from the procedures described in section 2450-D and 2450-E of standard methods [23]. Spectrophotometer (DR-2800) was used to measure COD as referred to the reactor digestion method adapted from Jirka and Carter [24] and VA (as referred to esterification method) adapted from Montgomery et al. [25]. The measurement of COD in the current study was based on soluble COD. All feed and effluent from the reactor were filtered using GA filter paper before the COD measurement.

3. Results and discussion

3.1. COD removal

Fig. 2 shows the COD removal profile and the fractional contribution of all the compartments in the MABR system treating synthetic wastewater. The total COD removal efficiency was 99.7% when the reactor was operated at an OLR of 0.258 kgCOD/m^3·d. However, when the OLR was increased slightly to 0.787 kgCOD/m^3·d, a minor reduction of the COD was observed (95%). The further increase of OLR to 2.471 kgCOD/m^3·d (shock loading), resulted in a dramatic reduction of the COD removal efficiency to 39.5%. The drastic increase of the OLR caused a dramatic decrease in the MABR overall COD reduction. This is inconsistency with other effects of OLR studies in anaerobic reactors [26].The fractional contribution of COD removal by each compartment of the MABR shows similar trends for all the OLRs studied with the order of C1 > C2 > C3 > C4 which is a normal pattern for anaerobic biore-

Table 2
Reactor operational conditions at different OLRs

HRT (d)	Initial COD (mg/l)	OLR (kgCOD/ m^3·d)	Study period (d)
4	1032	0.258	1–16
4	3148	0.787	17–23
4	9884	2.471	33–48

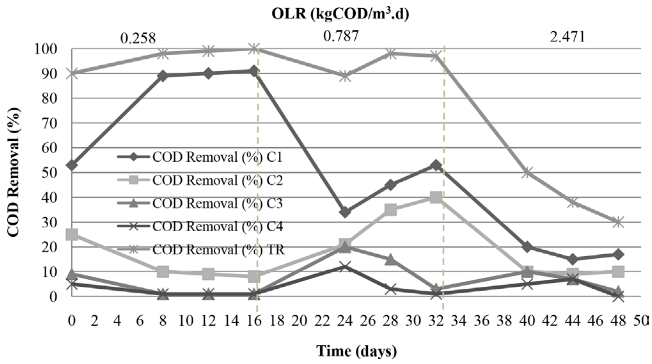

Fig. 2. Total COD reduction (%) of MABR and fractional contribution (%) to the total COD reduction by each compartment at different OLR.

actors that have different compartments or stages [27,28]. During the OLR of 0.258 kgCOD/m^3·d, the average COD removal efficiency in C1 was 89.8%, while the other compartments (C2, C3, and C4) contributed less than 10%. When the OLR was increased to 0.787 kgCOD/m^3·d, the average COD removal efficiency in C1 decreased to 43.5%, and the excess organic loading rate was successfully distributed in C2, with an average COD removal efficiency of 33.2%. The remaining compartments (C3 and C4) contributed less than 10% of the total COD removal. On the other hand, at an OLR of 2.471 kg COD/m^3·d, the average COD removal efficiency in C1 falls below 20%, with C2, C3 and C4 contributed less than 10%.

Several researchers have modified the ABR systems and better reactor performances were recorded. Table 3 illustrates some of the comparison between the present study and other researchers. Ghaniyari-Benis et al. [29] investigated a laboratory-scale multistage anaerobic biofilm reactor of three compartments with a working volume of 54 L for the treatment of synthetic medium-strength wastewater containing molasses as a carbon source at different operational conditions. Results showed that COD removal percentages of 91.6, 91.6, 90.0 and 88.3% were achieved at OLRs of 3.0, 4.5, 6.75 and 9.0 kgCOD/m^3·d, respectively. They also reported that a decrease in HRT from 24 to 16 h had no effect on COD removal efficiency. The same researchers also evaluated the performance of a multistage anaerobic biofilm reactor (Table 2), with six compartments and a working volume of 70 L, for the treatment of a strong synthetic nitrogenous and high-strength wastewater [30]. By increasing the HRTs from 6 h to 1 day, COD and BOD removal efficiencies were increased from 63 to 84% and from 66 to 87%, respectively. Other investigations (e.g. Doaa et al. [13], Alkarimiah et al. [14], and Bassuney et al. [15]) on the treatment of synthetic wastewater containing glucose in the ABR system were also presented in Table 2. The above result shows that each treatment system has its own advantages and disadvantages depending on the wastewater characteristics, reactor configuration, seed sludge and operational conditions. In the present investigation, up to 99.7% COD removal was achieved at OLR of 0.258 kgCOD/m^3·d. However, a poor reactor performance was noticed at OLR of 2.471 kgCOD/m^3·d, probably due to the high production of volatile fatty acids (Fig. 5) that affected the anaerobic digestion at this OLR.

Table 3
Comparison of different operational conditions at similar studies using ABR

Comparison	Present study	Ghaniyari-Benis et al. [29]	Ghaniyari-Benis et al. [30]	Doaa et al. [13]	Alkarimiah et al. [14]	Bassuney et al. (15)
Volume (L)	28	54	70	30	90	30
Type of wastewater	Synthetic (glucose)	Synthetic (molasses)	Synthetic (molasses)	Synthetic (glucose)	Synthetic (glucose)	Synthetic (glucose)
Compartments	4	3	6	5	4	5
HRT (d)	4	0.67,0.33,1	0.25, 0.67, 1, 3,5	3	1, 1.4	3
Total operation period (d)	48	35	185	53	90	34
Temperature range (C°)	37	35	26	35	37	35
OLR range (kgCOD/m³·d)	0.258, 0.787, 2.471	3.00, 4.50, 6.75, 9.00	10.00	1.80, 2.00, 3.00, 4.80,	0.82, 1.07, 1.22, 1.63, 2.45	1.20, 1.80, 2.00
Optimum OLR (kgCOD/m³·d)	0.787	4.50	10.00	1.80	2.45	1.8
Max COD removal at optimum OLR (%)	95.0	91.6	93.0	94.44	92	94.44
Residual VFAs concentration (as acetic) at the optimum OLR	<150	223	25	Not evaluated	Not evaluated	Not evaluated

Similar studies by Ghaniyari-Benis et al. [31,32] on the fractional conversion corresponded to the changes in HRT. The variation of the fractional conversion in the entire MABR corresponded to the changes in the feed OLR (Fig. 3). The fractional conversion was observed to be between 0.85–0.75 during OLR = 0.258 kgCOD/m³·d. The fractional conversion was stable until the next phase of the study. When the OLR was increased to 0.787 kgCOD/m³·d the fractional conversion had a drastic decrease from 0.75 to 0.44. The increase in OLR caused this obvious change in the fractional conversion. The anaerobic microorganisms in the reactor took a week to recover from the shock load, and then at day 27 the fractional conversion increased drastically to 0.71. The anaerobic microorganisms were introduced to a much higher OLR (2.471 kgCOD/m³·d) at day 34 onwards; the fractional conversion starts to show a fluctuating trend. At the beginning, a sudden increase in the fractional conversion was observed (0.86–0.93) then after day 40, the fractional conversion was reduced to 0.77 and achieved stability up to day 46. Then at the end of reactor operation, the fractional conversion took a nosedive to 0.435.

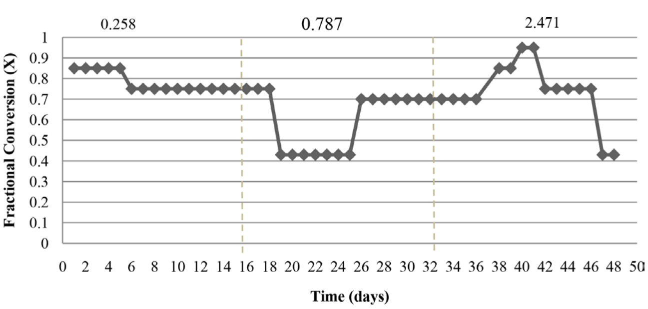

Fig. 3. Fractional conversion in MABR at HRT 4 days.

3.2. pH

Fig. 4 shows the pH profile across the MABR system when the OLR was gradually increased. It can be seen that the profile follows the order of C1 < C2 < C3 < C4, which is a common pattern in ABRs system. However, no significant difference in the pH profiles was observed in the all compartments, due to the effect of effluent recirculation. It is known that in the ABR system, the first compartments were populated mostly with the fast growing

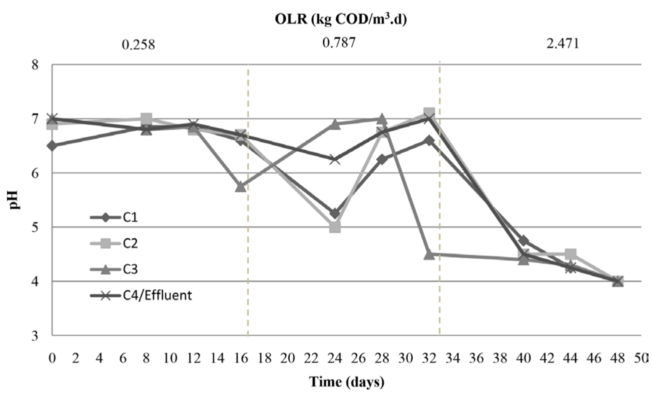

Fig. 4. pH profile in each compartment of MABR at different OLR.

acidogens [33]. In the later compartments, the slow growing methanogens were predominated, and this causes the difference in the pH profile across the reactor system. However, due to the effluent recirculation, more methanogens were introduced in the initial compartments of the reactor, and this caused the pH values for each compartment to be almost the same. At OLR of 0.258 kgCOD/m³·d, the pH in C4 was quite stable with an average value of 6.78. A slight decrease in the pH profile was observed at OLR of 0.787 kgCOD/m³·d, probably due to the adaptation of the microorganism to the new OLR. A pH of 7.01 in C4 signifies that the reactor could adapt to this OLR. However, further increase of the OLR to 2.471 kgCOD/m³·d resulted in a sudden drop in the pH profile to 4 and 5. This acidic condition is not suitable for the anaerobic digestion and proof that the MABR system could not withstand the high OLR [34]. At high OLRs, the organic substances were not well metabolized by the anaerobic bacteria and more production of VFA's leads to the lower level of pH.

3.3. Volatile fatty acid (VFAs)

Volatile fatty acids (VFAs) can be used as a tool to evaluate the anaerobic reactor performance. The more VFAs being utilized inside the reactor, the better the reactor performance is. According to Damasceno [35], total volatile fatty acids (TVFAs) less than 150 mg/l in an anaerobic reactor, indicates that the reactor was operated under stable conditions. During the degradation process of glucose in an anaerobic reactor, the acetic acid is the primary produced VFAs, hence it's important to evaluate its degradation [36]. In general, if the pH of the reactor system is high, the VFAs should be lower [37,38], and in the current study, this trend was clearly observed (Figs. 4 and 5). At OLR of 0.258 kgCOD/m³·d, the average VFAs concentration, as acetic acid, was less than 150 mg/l, confirming a stable reactor performance. Higher VFAs concentration was observed in C1 and C2 of the reactor, when the OLR was increased to 0.787 kgCOD/m³·d. However, stable VFAs concentration was observed in C3 and C4, as in the earlier OLR, suggesting that stable reactor performance in these two compartments. The further increase in the OLR to 2.471 kgCOD/m³·d demonstrated a sudden increase in the VFAs (2800 mg/l, as acetic) in the all compartments of the MABR system, confirming the accumulation of VFAs at this OLR [39].

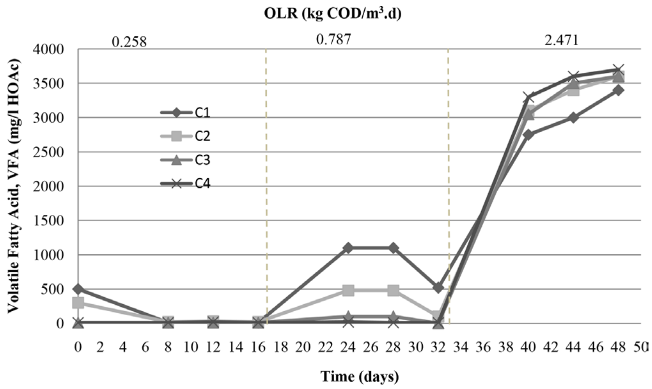

Fig. 5. VFAs profiles for each compartment at different OLRs.

3.4. Solid washout and biogas yield

Both solid washout and biogas production can be an obvious sign of the reactor performance. Table 4 shows the VSS and biogas profile in each compartment of the MABR system at different OLRs. At OLR of 0.258 kgCOD/m³·d, low VSS was observed in C4 (40 ± 14 mg/l) of the reactor system confirming low solid washout from the reactor. Simultaneously, the average biogas yield was 0.542 L/ $gCOD_{removed}$. A slight increase in the VSS was observed at OLR of 0.787 kg COD/m³·d with C4 having an average VSS of 43 ± 14 mg/l. At OLR of 0.787 KgCOD/m³·d, the average biogas yield decreased slightly to 0.514 L/$gCOD_{removed}$. The presence of the baffles in MABR minimizes the escaping of suspended solids, as it is relevant in retaining the active biomass within the reactor. Hence, this will contribute to higher COD removal rate [40]. However, much different situation was observed at OLR of 2.471 kgCOD/m³·d where an average VSS of 190 ± 10 mg/l was registered in C4, suggesting high solid washout from the reactor system. The average biogas yield during this period was 0.213L/$gCOD_{removed}$, confirming the system's performance deterioration. These results could be compared to the COD removal profile where the biogas yield was high when high COD removal efficiency in the reactor.

The above result on the solid removal can be compared with other findings, although there were limited numbers of research papers in the study of solid washout from ABR using glucose as a carbon source. Alkamariah et al. [14] reported an average solid washout of 150 mg/l at OLR of 1.07 to 2.45 kgCOD/m³·d during the start-up of a multi-stage

Table 4
Sludge washout and biogas yield of MABR at different OLR

		OLR (kg COD·m⁻³·d⁻¹)		
		0.258	0.787	2.471
VSS (mg/l)	Compartment 1	87.5 ± 18	243.3 ± 12	646.7 ± 40
	Compartment 2	40.0 ± 15	60.0 ± 15	293.3 ± 30
	Compartment 3	46.7 ± 10	40.0 ± 14	246.7 ± 25
	Compartment 4	40.0 ± 14	43.0 ± 14	190.0 ± 10
Methane yield ($L/gCOD_{removed}$)		0.542	0.514	0.213

anaerobic reactor (a modification of ABR) using glucose as a substrate. An average VSS of 29 mg/l at OLR of 2 kgCOD/m^3·d was observed by Gopala Krishna [41] during the treatment of synthetic wastewater containing sucrose in an ABR. There are also some reported studies on the solid washout from ABR using real wastewater. Feasibility of the ABR process was investigated for the treatment of wheat flour starch wastewater by Movahedyan et al. [42]. The system showed high solids retention with effluent SS concentration of 50 mg/l at OLR of 2.5 kgCOD/m^3·d. Interestingly, an investigation by Tawfik et al. [43] revealed a VSS washout of 1000 mg/l when the ABR was fed with starch wastewater at OLR of 7.4 kgCOD/m^3·d. Boopathy et al. [44] reported a VSS washout of 400 mg/l during the treatment of distillery wastewater in an ABR at OLR of 2.6 kgCOD/m^3·d. Bwapwa [45] reported an ABR treating low biodegradable wastewater (blackwater) has VSS removal of 53 to 90% at different initial COD concentrations ranged from 1500 to 3000 mg/l. Uyanik et al. [46] observed a solid washout during the treatment of ice-cream wastewater by ABR at several OLRs and their results showed an effluent VSS of 870 mg/l at OLR of 5.18 kgCOD/m^3·d. In the present investigation, a relatively high solid washout (190 ± 10 mg/l) was noted at OLR of 2.471 kgCOD/m^3·d compared to some of the studies above using glucose as substrate. The above differences on the removal of solids from ABR reveal that each investigation is unique and depends on many factors such as wastewater characteristics, seed sludge, reactor configurations, operating conditions, etc.

4. Conclusion

The main aim of this study was to evaluate the performance of modified anaerobic baffled reactor (MABR), supported by slanted baffles, at different OLRs. It was observed that the reactor could not perform at OLR of 2.471 kgCOD/m^3·d, probably due to the high organic substances which could not be metabolised by the microorganisms. At lower OLRs (0.258 and 0.787 kgCOD/m^3·d), the metabolism was high where the microorganisms can digest the organic substances. This was clearly noted in the pH and VFAs profiles (sudden drop in the pH profile to 4 and 5 and VFA increase to 2800 mg/l, as acetic), which showed that the organic substances were not well metabolized by the anaerobic bacteria. The solid washout in the MABR system varied with typical levels of 40 ± 14 – 190 ± 10 mg/l (effluent) for all the OLRs. The low level of solid washout from the MABR confirms that the slanted baffles added to each compartment prevented the solid washout to a certain extent, although the observed VSS concentrations are normal to be low using synthetic wastewater. For future work, an investigation should be conducted on real wastewater in the MABR system at elevated OLR to assess the effectiveness of the slanted baffles.

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