EFFECT OF BIOFILM FILLING RATES, VARIOUS CYCLES DURATION AND ORGANIC LOADING RATES ON ORGANIC AND NUTRIENTS REMOVAL IN SEQUENCING BATCH BIOFILM REACTOR (SBBR)

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Abstract - *This research investigated the effect of changing media filling rates, various cycles duration in the SBR process and changing the organic loading rates on the removal of organic and nutrients from a medium strength synthetic wastewater (COD 420 mg/l.). A laboratory-scale bioreactor has been fabricated and installed in Imyay W.W.T.P. The experiment was performed at three phases; the first phase was to investigate the effects of changing the media filling rates, the second phase was to study the effects at various cycles duration and the third phase was to investigate the treatment efficiency at different organic loading rates. The solid retention time (SRT) was 11 days and flow rate of (1.70 L/Hr.). Complete cycle duration was 12 hours and MLVSS was adapted to be 1200 mg/l by letting the excess sludge to be removed from the reactor. The biological oxygen demand (BOD) removal was 91.2, 93.6 and 94.0% for media filling rate of 0, 50 and 25% respectively. Also, the removal rates for the same test was 94.0, 93.5 and 92.2% for aeration-settling cycle duration (8-2), (7-3) and (6-4) hours respectively. Finally, the removal rates at this test was 94.0 and 95.6% for OLR of 0.84 and 1.44 (Kg COD/m3.day). The chemical oxygen demand (COD) removal was 89.1, 91.7 and 92.7% for media filling rate of 0, 50 and 25% respectively. Also, the removal rates for the same test was 92.7, 91.7 and 90.6% for aeration-settling cycle duration (8-2), (7-3) and (6-4) hours respectively. Finally, the removal rates at this test was 92.7 and 94.8% for OLR of 0.84 and 1.44 (Kg COD/m3.day). Total nitrogen (TN) removal was 39.2, 50.9 and 53.2% for media filling rate of 0, 50 and 25% respectively. Also, the removal rates for the same test was 53.2, 55.5 and 57.5% for aeration-settling cycle duration (8-2), (7-3) and (6-4) hours respectively. Finally, the removal rates at this test was 53.2 and 49.5% for OLR of 0.84 and 1.44 (Kg COD/m3.day). Total phosphorus (TP) removal was 63.5, 71.8 and 72.3% for media filling rate of 0, 50 and 25% respectively. Also, the removal rates for the same test was 72.3, 73.3 and 76.4% for aeration-settling cycle duration (8-2), (7-3) and (6-4) hours respectively. Finally, the removal rates at this test was 72.3 and 83.4% for OLR of 0.84 and 1.44 (Kg COD/m3.day).*

Key Words: tertiary treatment, SBBR, wastewater treatment

1. INTRODUCTION

Conventional activated sludge process is not designed to remove nitrogen [1-3]. Because of its short detention time, the sludge produced is not well digested so it needs extra an additional sludge digestion treatment [4-5]. Since the 1970s, an alteration of (ASP) has made the emergence of the (SBR) process [6-7]. Conventional (ASP) systems are area oriented, but the (SBR) system is a time oriented as all process are controlled in one tank [8-10]. Several lab-scale SBR studies have shown the efficiency of the SBR in treating municipal and industrial wastewater. SBR technology is used for BOD removal, nitrification, de-nitrification and phosphorus removal. At 1985 Irvine displayed that a full-scale SBR operating for treating municipal wastewater achieved effluent limits of 10 (mg/l) BOD5, and 10 (mg/l) TSS, 1 (mg/l) biological phosphorus and 14 (mg/l) ammoniacal nitrogen equivalent to 98% BOD5 removal, 97% TSS removal, 92% TP removal and 70% NH4-N removal [11]. At 1997 Surampalli initiate that the average removal efficiency was in the range 88 - 98 % for BOD5; 84.65 - 97.15% for TSS; 90.75 - 96.75% for ammonia; 56.55 % for total nitrogen and 57.45 - 83.50 % for phosphorus in 19 municipals and private SBR wastewater treatment plants in the United States of America [12]. Silva at 2001 observed reduction of 95 % for various concentrations of NH4+ and phosphorus, an anaerobic/aerobic (or anoxic) order was essential to endorse biological phosphorus removal.

pH Effect

The pH of the medium affects the nitrification process and phosphorus removal. Surampalli observed an optimum pH range of 7.5 - 9.0 while Smolders at 1994 observed that phosphorus uptake ratio enlarged with increasing pH. Though, the ratio reduced at pH values above 8.0 [13].

Temperature Effect

The optimal operating wastewater temperature is around 30o C for both anaerobic release and aerobic up take of phosphate.

SRT Effect

Kargi at 2002 found the maximum removal efficiencies for COD (94.50 %), nitrogen as NH4–N (84.75 %) and phosphorus as PO4–P (70.30 %) were found at the sludge age of about 10 days. Extreme growth of protozoa and rotifers happened under sludge age over 15 days [14].

Volumetric Exchange Rate

According to Antonio at 2003 reported that VER values range between 25-50%. High VER value is usually regarded as beneficial for avoiding sludge bulking due to substantial gap of the organic substrate produced between before and after feed-filling in the reactor.

2. METHODOLOGY

2.1. Lab-Scale Reactor

The experimental was carried out using a lab-scale reactor (Three phases) the first phase simulated the SBR processes without media as stage one, stage two was for simulation the SBBR processes after adding biofilm media with 50 % filling rate in the same tank, then the third stage changes the filling rate to 25 %. The second phase was to study the effect of changing the cycle's retention time (aeration & settling). Finally, the third phase shows the effects of OLR changing; the conventional SBR and SBBR process for phase one as illustrated in the below Fig.

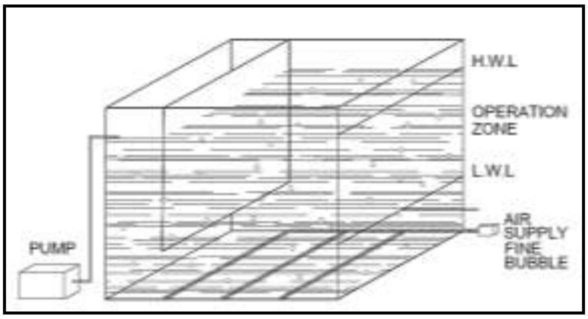

Figure 1. Phase 1 - Stage 1 (No Media)

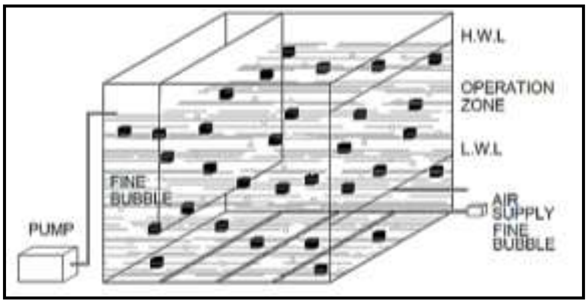

Figure 2. Phase 1 - Stage 2 (50% Media)

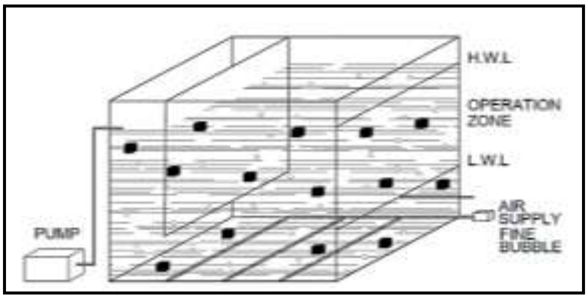

Figure 3. Phase 1 - Stage 3 (25% Media)

A laboratory scale reactor with the dimensions of 40 cm × 25 cm × 35 cm (L×W×H) and a working volume of 20 L has been fabricated using glass because it is not easy to be deformed, and easy to observe the biofilm carriers and sludge in the reactor. A baffle wall was installed at the entrance of the reactor to increase the flow. The system was built up and installed in Imyay Wastewater containing two submersible pumps (flow controlled) for feeding the reactor with the synthetic wastewater and wasting the excess activated sludge from the system with flow rate (1.50 L/Day). The system also contained air blowers (1.70 L/Hr.) The following figure presenting the schematic diagram for the lab-scale reactor process.

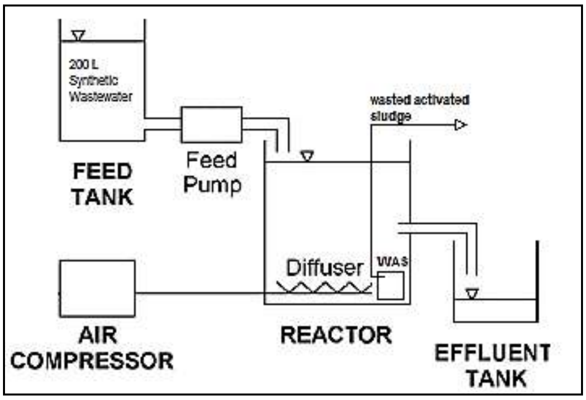

Figure 4. Schematic diagram for the lab-scale process

2.2. Synthetic wastewater

Synthetic simulates a real domestic wastewater and intended, which contains biodegradable organic pollutants with a constant concentration in its characteristics that lead to a high accuracy analysis. The C: N: P ratio is 100: 10: 1.9 that very similar to the domestic wastewater, the composition and its concentration is shown in the below table.

Table 1. Synthetic wastewater compounds

Compound	C.F	mg/l
Peptone	-	25
Na-acetate	C2H3NaO2	120
Meat extract	-	25
Glycerol	C3H8O3	55
Potato starch	-	55
Milk powder	-	120
Urea	CH4N2O	80
Ammonium chloride	NH4Cl	25
Potassium dihydrogen orthophosphate	KH2PO4	35
Magnesium sulphate	MGSO4	10

This synthetic sample gives a mean COD of 420 mg/l. as shown in the below table.

Table 2. Synthetic wastewater concentration

Parameter	Value	Unit
PH	7.8	-
COD	420	PPM
BOD5	280	PPM
TN	42.4	PPM
TP	7.85	PPM

2.3. Biofilm media

A moving bed FAB media with a large surface area of 400 m2 /m3 made of polyethylene with a density of about 0.93 gm/cm3, which is locally manufactured, was used in SBBR phases, shown below.

Figure 5. Moving bed media

Table 3. Technical specification of the moving bed

Effective specific surface area	400	m2/m3
Media height	15	mm
Media diameter	20	mm
Weight per unit surface area	0.37	kg/m2
Specific gravity	0.90-0.95	g/cm3
Voids	> 98	%
Density	0.93	g/cm3
Media fill rate range	25-55	%

2.4. Working plan

This thesis study how efficient of the biological treatment and nutrient removal for the SBR and SBBR systems, the two systems works 2 cycle per day each cycle lasted for 12 h and contained five phases: influent (1.0 h), aerobic reaction (8.0 h), sedimentation (2.0 h) and decanting (1.0 h) [15]. The experiment has been studied several variables where it divided into three main phases shown below.

PHASE ONE

This phase has studied the media filling rate on the biological treatment and nutrient removal in the SBR and SBBR system, all other parameters was fixed such organic loading rate, Hydraulic retention time and cycle duration.

Phase one has divided into three stages. Stage one has no media as a simulating of sequencing batch reactor system (SBR), in stage two the moving media were added by 25 % of the reactor volume but in the final, stage the filling ration changed from 25 % to 50 %.

PHASE TWO

This phase has studied the changing in aeration, settling cycle's duration and it is reflecting on the biological treatment, and nutrient removal in the Sequencing Batch Biofilm Reactor System (SBBR), all other parameters was fixed such organic loading rate and media-filling rate.

Phase two has divided into three stages. Stage one the aeration cycle was 8 hours and the settling cycle was 2 hours, in stage two the aeration cycle decreased to be 7 hours and increasing the settling cycle to be 3 hours, finally the third stage the aeration cycle decreased to be 6 hours and the settling cycle increased to be 4 hours.

PHASE THREE

This phase has studied the effect of changing the organic loading rate (COD), it is reflecting on the biological treatment, and nutrient removal in the Sequencing Batch Biofilm Reactor System (SBBR), all other parameters was fixed such cycle duration and media-filling rate.

Phase three has divided into two stages. Stage one the biological load was 420 mg/l and in cycle two the biological load increased to be 720 mg/l.

3. RESULTS & DISCUSSION

Start-up phase took about 45 days to reach the SteadyState operation. System start-up took 15 days then it took 30 days to let the biofilm to be formed on the moving media. The BOD removal rate reached 524.00 gm/day/m3, COD removal rate was 783.80 gm/day/m3, Total nitrogen removal rate reached 36.40 gm/day/m3 and finally for the total phosphorus removal rate was 10.90 gm/day/m3. The experiment has been divided into three main phases, phase one illustrates the relation between various carrier-filling rates and its corresponding removal efficiency on various analysis as shown in the following figure.

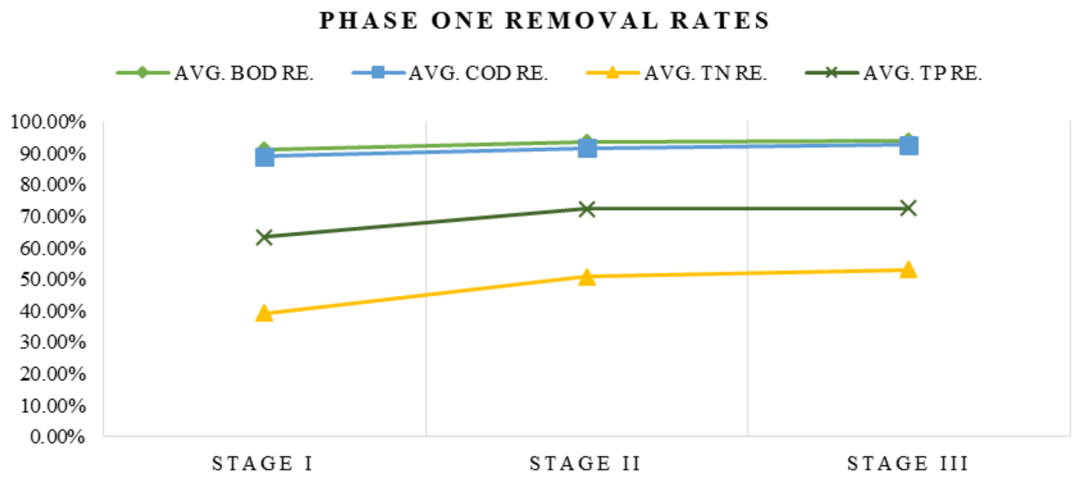

Figure 6. Average removal rates for phase one

The pervious results indicate that average BOD5 removal at 0, 50 and 25 % carrier filling rates were 91.2, 93.6 and 94.0 % respectively. Although BOD5 removal efficiencies were more than 90% at all the carrier filling rates, average removal efficiency of 25 % carrier filling rate was found to be slightly higher and steadier which may be as a result of an active biofilm layer presence on the carrier's surface. It has been widely recognized that excessive biofilm growth can result in process impairment by reducing the effective biofilm surface area due to physical clogging, declining the biofilm reactiveness due to distribution limits of vital nutrients and accumulation of endogenous bacteria. In attached growth systems, problems linked with excessive biofilm can take place both in fixed bed and moving bed systems because of insufficient or unsuitable mixing patterns [16]. The average COD removal efficiency was significantly affected by different filling rates. 89.1, 91.7, and 92.7% COD removal efficiency were obtained at 0, 50 and 25% carrier filling rates, respectively. It can be seen that COD removal efficiency increased up to 3.60 % with increasing carrier filling rate from 0% to 25% (Figure 6). However, adding higher number of carriers (50%) into the reactor led to a decrease in COD removal efficiency which might be due to the accumulation of biomass on carrier's surface. TN removal was also monitored during the experiment at the different filling rates. Basically, total nitrogen removed from wastewater by biological nitrification and denitrification process under aerobic and anaerobic conditions. The average TN removal efficiency at filling rates of 0, 50 and 25 % were 39.20, 50.80 and 53.20% respectively shown in figure 6, the results indicate that TN removal efficiency increased after using media in the reactor, however the removal efficiency decreased significantly with increasing the number of carriers in the reactor as 25% media filling rate is more efficient than 50 % filling rate according to figure 6. Another parameter was observed during the experiment which is TP. The average TP removal rates was 63.50, 72.40 and 72.60 % at 0, 50 and 25% filling rate respectively shown in figure 6, the results indicate that TP removal efficiency increased after using media in the reactor, however the removal efficiency decreased significantly with increasing the number of carriers in the reactor as 25% media filling rate is more efficient than 50 % filling rate according to figure 6.

It has been observed that biofilm density on carriers in SBBR system plays a key role in system performance and 25% filling rate can provide sufficient amount of biomass on carriers for TP and TN removals, but in higher filling rates it leads to competition for enough oxygen and space which occurs between heterotrophs and nitrifies. The following table summarize phase one removal efficiency according to filling rate changes.

Table 4. Average removal rates for phase one

STAGE NO.	MEDIA FILLING RATES	CYCLE DURATION (AERATION-SETTLING)	ORGANIC LOADING RATE (Kg COD/m3.day)	AVG. BOD5 RE*	AVG. COD RE*	AVG. TN RE*	AVG. TP RE*
ONE	0 %	(8 – 2) HOURS	0.84	91.2 %	89.1 %	39.2 %	63.5 %
TWO	50 %	(8 – 2) HOURS	0.84	93.6 %	91.7 %	50.8 %	72.4 %
THREE	25 %	(8 – 2) HOURS	0.84	94.0 %	92.7 %	53.2 %	72.6 %

RE: REMOVAL EFFICIENCY

Phase two illustrates the relation between various cycles durations and its corresponding removal efficiency on various analysis as shown in the following figure.

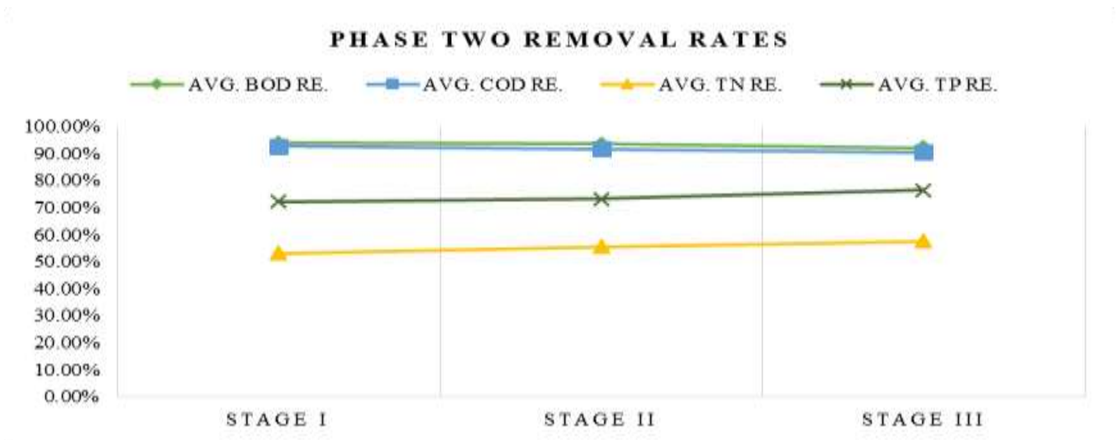

Figure 7. Average removal rates for phase two

The pervious results indicate that average BOD5 removal at (8 – 2) hours, (7 – 3) hours and (6 – 4) hours cycle durations were 94.0, 93.5 and 92.2 % respectively. Although BOD5 removal efficiencies were more than 90% at all the carrier filling rates, average removal efficiency of (8 – 2) hours cycle duration was found to be slightly higher and steadier which may be according to the higher aeration time which lead to long contact time between carriers and the influent, more react period and more reaction time. Table 4.2 shows that the average COD removal efficiency was significantly affected by different cycle durations. 92.7, 91.7, and 90.6% COD removal efficiency were obtained at (8 – 2) hours, (7 – 3) hours and (6 – 4) hours cycle durations, respectively. It can be seen that COD removal efficiency increased up to 2.10 % with increasing the aeration cycle from 6 to 8 hours which lead to higher contact time between the influent and the microorganisms. (Poonyachat, 2001) found that decreasing the aeration cycle lead to lower performance on organic removal in terms of BOD and COD. However, the same trend for the effect of aeration cycle on COD removal efficiency was achieved in this study TN removal was also monitored during the experiment at the different cycle durations. Basically, total nitrogen removed from wastewater by biological nitrification and denitrification process under aerobic and anaerobic conditions. The average TN removal efficiency at cycle duration of (8 – 2) hours, (7 – 3) hours and (6 – 4) hours were 53.20, 55.50 and 57.50% respectively shown in figure 7, the results indicate that TN removal efficiency increased by increasing settling period, Figure (7) demonstrates that the TN removal efficiency was higher at shorter aeration cycle and longer settling cycle. This significant increase in the trend of TN removal from the first stage to the third stage, could be attributed to the active biofilm layer presented on carrier's surface at the lowest aeration cycle which resulted in augmentation of the nitrification rate. Also increasing the settling cycle cause more activity of denitrification process. Niaki (2000) had the experiment to implementation of nutrient removal by using SBR [17]. The results can show that nitrogen removal by SBR system increases when anoxic cycle increases from one to 1.5 hours and decreased the effluent nitrate concentration by 53% [18]. Another parameter was observed during the experiment which is TP. The average TP removal rates was 72.30, 73.30 and 76.40 % at cycle duration of (8 – 2) hours, (7 – 3) hours and (6 – 4) hours respectively shown in figure (7), it aslo shows the remarkable increase of TP removal efficiency by decreasing the aeration cycle duration and increasing the settling cycle duration. Increasing the settling cycle lead to create an anaerobic condition in the same tank with the existing aerobic condition causes (PAO) Phosphate Accumulating Organisms formation which use phosphorus as an Energy storage mechanism. The following table summarize phase two removal efficiency according to cycle duration changes.

Table 5. Average removal rates for phase two

STAGE NO.	MEDIA FILLING RATES	CYCLE DURATION (AERATION-SETTLING)	ORGANIC LOADING RATE (Kg COD/m3.day)	AVG. BOD5 RE*	AVG. COD RE*	AVG. TN RE*	AVG. TP RE*
ONE	25 %	(8 – 2) HOURS	0.84	94.0 %	92.7 %	53.2 %	72.3 %
TWO	25 %	(7 – 3) HOURS	0.84	93.5 %	91.7 %	55.5 %	73.3 %
THREE	25 %	(6 – 4) HOURS	0.84	92.2 %	90.6 %	57.5 %	76.4 %

RE: REMOVAL EFFICIENCY

Phase three illustrates the relation between various organic loading rates and its corresponding removal efficiency on various analysis as shown in the following figure.

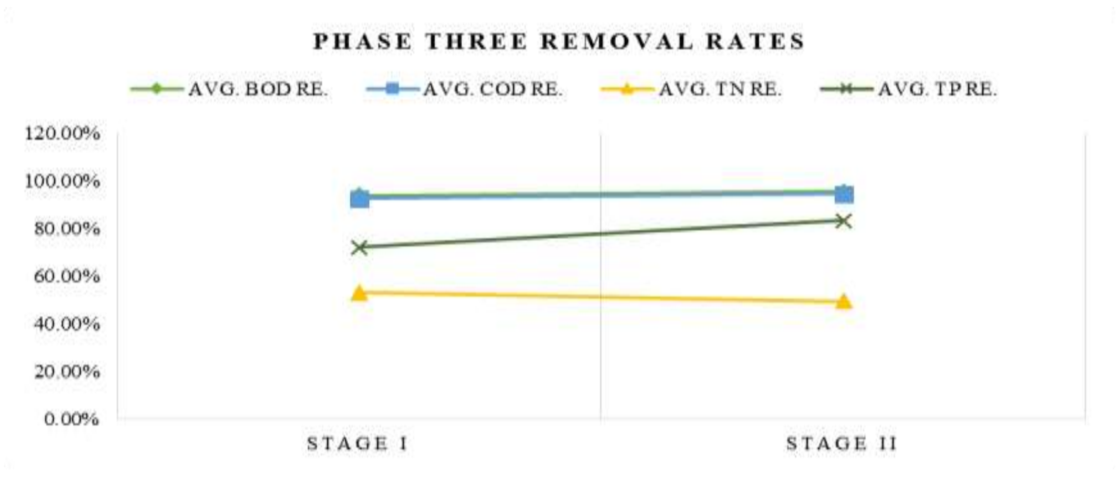

Figure 8. Average removal rates for phase three

The pervious results indicate that average BOD5 removal at 0.84 and 1.44 Kg COD/m3.day were 94.0 and 95.6% respectively. Although BOD5 removal efficiencies were more than 90% at all the organic loading rates, average removal efficiency of 1.44 Kg COD/m3.day organic loading rate was found to be slightly higher and steadier. Low BOD removal efficiency at OLR of 0.84 kg COD/m3. D could be related to the lack of food existent in the influent that was caused by low influent COD concentration. It can be obviously seen from Figure 8 that the highest BOD removal efficiencies were achieved at 1.44 kg COD/m3. d. This could be explained as result of enhancement of microbial growth and augmentation of their attachment on PE carriers when the OLR was increased. The results of COD removal with SBBR showed a similar trend as that of BOD removal at different OLRs. Average COD removal efficiency increased from 92.70 to 94.80% with increasing OLR from 0.84 to 1.44 kg COD/m3. D, respectively. It was reported that higher COD removal efficiency could be achieved at higher OLR in the aerobic reactor [19]. This indicates that a higher OLR could enhance the activity of aerobic microorganism. Although at the beginning of each phase, where OLR was increased, there was a corresponding decrease in COD removal efficiency, the system recovered shortly and adapted to the new conditions with time as it was expected. Hajipour (2011) found the same trend in COD removal efficiency at different OLRs [20]. Aerobic thermophilic MBBR was used in their experiment and it was found that the COD removal efficiency increased primarily with increase in OLR. However, after it reached to a constant value at OLR of about 6 kg COD/m3. D, COD removal efficiency started to decrease significantly.

Nitrogen is normally removed biologically from wastewater with nitrification of ammonia to nitrate under aerobic conditions, followed by denitrification of nitrate to nitrogen gas under anoxic conditions. The outcomes of TN removal showed augmentation of removal efficiency rate from 49.50 to 53.20% when the OLR decreased from 1.44 to 0.84 kg COD/m3. D, respectively. This may be due to lowering organic carbon concentrations that enhances denitrification process. This is due to the lack of space and oxygen for the bacteria that consumes organic carbon and bacteria consuming ammonia and nitrite. S.H. Mirhossaini (2010) indicate that biological ammonia removal is highly influenced by competition established between heterotrophic and autotrophic microorganisms [21]. This competition depends on the COD concentration in influent wastewater. The result of his study showed that the ammonia could be removed from wastewater in high quantity in extended activated sludge if COD concentration was adjusted. In influent COD concentration, 351.35±2.05mgL-1 can remove 79.84 percent of ammonia from wastewater. When influent COD is further than 351.35±2.05mgL-1, ammonia removal efficiency will decrease.

The effect of two different OLRs on nutrient removal is shown in table 4-3. Biological phosphorus removal is performed by phosphate accumulating microorganisms (PAO) that have the ability to accumulate phosphate over and above what is required for growth. Due to low influent COD at OLRs of 0.84 kg COD/m3. D, 72.30% of phosphate was removed. Gradually by increasing OLR from 0.84 to 1.44 kg COD/m3. D, phosphate removal increased up to 83.40%. The following table summarize phase three removal efficiency according to filling rate changes.

Table 6. Average removal rates for phase three

STAGE NO.	MEDIA FILLING RATES	CYCLE DURATION (AERATION-SETTLING)	ORGANIC LOADING RATE (Kg COD/m^3.day)	AVG. BOD_5 RE*	AVG. COD RE*	AVG. TN RE*	AVG. TP RE*
ONE	25 %	(8 – 2) HOURS	0.84	94.0 %	92.7 %	53.2 %	72.3 %
TWO	25 %	(8 – 2) HOURS	1.44	95.6 %	94.8 %	49.5 %	83.4 %

RE: REMOVAL EFFICIENCY

The microbial activity has been observed during all phases and from observation, it has been noticed that in phase one the microbial concentration was enhanced after using biofilm media. Figure (9) and (10) showing the microbial growth on 25 and 50% filling rate respectively. In phase two, it was too hard to observe the change in the microbial growth. However, in phase three it has been noticed that microbial concentration was enhanced with increasing OLR.

Figure 9. Microbial growth 25% media filling rate

Figure 10. Microbial growth 50% media filling rate

A light microscope was used to analysis the seeded biomass during the experimental figure (11) presenting the microscopic image (40×objective) showed to have mixed populations of both gram-positive and gram-negative microorganisms. In gram negative, most of the bacteria are in cocci and diplococci, whereas gram-positive bacteria are found in clusters.

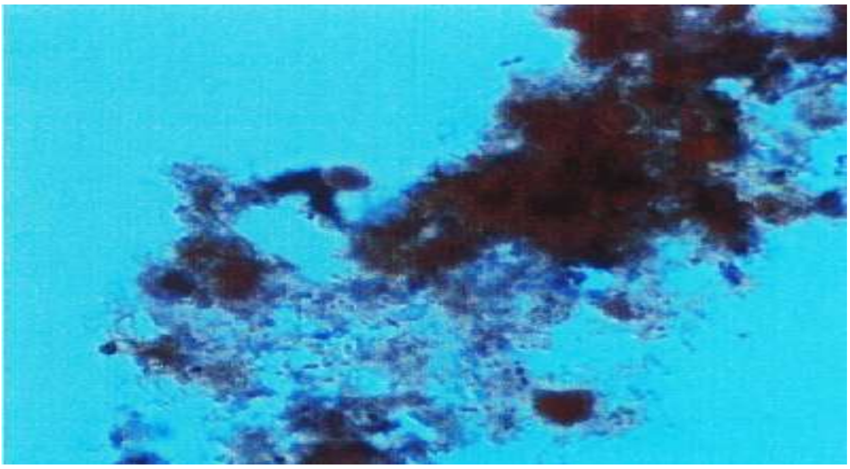

Figure 11. Biomass 40x magnification

A summary of several works focusing on removal efficiency of SBBRs for treatment of synthetic and raw wastewater is given in Table 7.

Table 7 Experimental studies on SBBR

REFERENCES	INFLOW	Media filling rate	Inflow COD (ppm)	Aeration (hrs.)	SRT (days)	Avg. COD RE*	Avg. TN RE*	Avg. TP RE*
This Research	synthetic wastewater	25 %	420.0	8	11	92.7 %	53.2 %	72.3 %
[22]	synthetic wastewater	4 %	7000.0	19	15	98.9 %	78 % 1	-
[23]	raw wastewater	Sponge	502.4	7	12	96.0 %	99.0 % 2	100 %
[24]	raw wastewater	Rock	344.0	1	12	71.0 %	-	-
[25]	raw wastewater	30 %	288.3	5	-	91.19 %	67.8 % 2	-
[26]	synthetic wastewater	10 %	332.0	4.3	26	97.6 %	65.4 %	97.2 %

RE: REMOVAL EFFICIENCY
1: (TKN) Total Kjeldahl Nitrogen removal
2: NH3-N removal

4. CONCLUSIONS

The objective of this study was to optimize the performance of lab-scale reactor simulating sequencing batch biofilm reactors (SBBR) for organic and nutrients removal. The effects of operational parameters on removal efficiency were observed. In this study, the media filling rate, cycle duration and organic loading rate were varied. SBBR process is a very cost effective and eco-friendly option from organic and nutrients removal. The following conclusion can be drawn from this study:

1. SBBR system is more efficient than SBR. According to this study, adding 25% media to SBR system with 6 hours' aeration is more efficient than SBR system without media with 8 hours' aeration. Where, the removal efficiency increased from 91.20 to 92.15 %, 89.12 to 90.58 %, 39.22 to 57.45 % and 63.48 to 76.43 % for BOD, COD, TN and TP respectively.

2. Adding media to an existing SBR system leads to reducing in the hydraulic retention time that can effect on system efficiency by increasing its absorptive capacity thus increasing the footprint.

3. At 25% of carrier filling rate, carriers could move uniformly in 20 L reactor and give favorable surface area for microbial growth. As a result, higher BOD, COD, TN and TP removal efficiency were achieved at 25% filling rate compared to that of 50%.

4. Changing the (aeration-settling) cycle from (8-2) to (6-4) hours did not significantly affect the SBBR performance in terms of COD and BOD removal as an active biofilm layer was formed on biofilm carriers.

5. (Aeration-settling) cycle variation from (8-2) to (6-4) hours Resulted in augmentation of T-P and T-N removal efficiency from 72.29 and 53.18% to 76.43 and 57.45%, respectively.

6. SBBR was capable of retaining a considerable quantity of attached biomass, which would provide successful performance and achieve appreciable organic removal. Thus, the higher the OLR led to the greater the amount of attached biomass on support material that resulted in consumption of a greater part of the substrate by this biofilm.

7. The higher BOD, COD and T-P removal was occurred at the higher organic loading rate of 1.44 Kg COD/m3.day, otherwise the T-N removal was higher at the lowest organic loading rate of 0.84 Kg COD/m3.day.

8. Denitrification occurs primarily during the settle phase of the SBR operation so as the sufficient time required for anoxic denitrification should be calculated.

9. More biomass attachment on the media edges is correlated with the media ratio in the system as noticed in media ratio variation from 25 to 50 %.

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