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The SBR System Without Reaeration in Its Prolonged Idle Period for Treatment of Hospital Wastewater

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Abstract

The efficiency of the SBR system without reaeration in its prolonged idle period for treatment of hospital wastewater was investigated and compared to the one with reareation in that period. The lab-scale SBR system units were operated and tested for this purpose. The average concentrations of influent in the study were 226, 113, 36 and 136 mg/L for COD, BOD, TKN, and SS respectively. The experiment was performed in 2 parts: the MLSS concentrations of the system were at 2,400-2,600 mg/L for Part I, and at 1,400-1,600 mg/L for Part II. Results from Part I and Part II with and without reaeration showed efficiencies of greater than 90% in removing COD, BOD, TKN, and SS . Statistical Analyses revealed that the efficiency of the system unit without reaeration to remove COD and BOD was significantly lower than that of the one with reaeration for Part I. However, the COD, BOD, TKN, and SS removal efficiencies for the system units of part II, either with or without reaeration in the idle period, were not different. More importantly, the effluent characteristics of all system units were below the effluent standards. It could be concluded that the appropriate MLSS concentration for operating the SBR system without reaeration in the prolonged idle period should be in the range of 1,400-1,600 mg/L. This is because it not only achieves similar removal efficiency as the system with reaeration but also reduces the power and energy consumption.

Key Words: SBR system, idle period, reaeration, wastewater treatment,

1. Introduction

Domestic wastewater from various building sources such as hospitals, hotels, condominiums, and restaurants are subject to the building effluent standards set by the Ministry of Science, Technology, and Environment.[1] The effluents from these building sources have to meet the effluent standards before being discharged into any public channels or natural waterways. Hence, the regulated building owners need to construct, install, or provide a wastewater treatment system or equipment to achieve the desired effluent quality. This inevitably leads to increased costs from both investment and operation. Hence, the development of appropriate treatment methods with low construction cost, easy operation, and maintenance will be worth considering.

The Sequencing Batch Reactor (SBR) system may be one of the treatment systems suitable for a small community because of its batch operation and the variation of domestic wastewater flow rate. Situations with flow in excess of six times the normal average flow rate, together with prolonged period of no flow are not uncommon wastewater characteristics[2] for a small community. However, the SBR system can perform to serve both fluctuated flow rate and varied loading without degradation on effluent quality.[3] The SBR system is a fill-and-draw type reactor system involving a single complex-mix reactor in which all steps of the activated sludge process occurs. Mixed liquor remains in the reactor during all cycles, therefore eliminating the need for a separate secondary sedimentation tank. So less construction area is required.

During the SBR's prolonged idle period of no incoming wastewater to the reactor, the aerator is simply on function to preserve the microorganisms for the next treatment cycle. Obviously, power is unnecessarily wasted.

Hence, a SBR system without reaeration in its prolonged idle period, in order to minimize power consumption and conserve energy, is investigated. This research aims to determine the efficiency in removing organic, nitrogen, and suspended solids of a SBR system without reaeration in its prolonged idle period as compared to that with reaeration . In addition, efficiencies of the system at the MLSS concentrations of 1,400-1600 mg/L (F/M ratio 0.05) and of 2,400-2600 mg/L (F/M ratio 0.03) are also determined.

2. Materials and Methods

Lab-Scale SBR Units

The experiment involved an operation of 2 identical lab-scale SBR system units. The units comprised 2 reactors, 2 mixers, 2 aerators, 1 influent pump, 6 valves (2 for effluent drainage, 2 for sludge wasting and the other for controlling flow rate), 4 timers (2 for mixers and the other for aerators), 2 effluent tanks, 1 waste sludge tank, 1 static head tank and 1 influent tank. The schematic diagram of the units is shown in Figure 1. The 24 hour cycle of the SBR system was as follows: 1 hour for fill, 4 hours for anoxic react, 3.5 hours for oxic react, 1 hour for settle, 0.5 hour for draw, and 14 hours for idle. The 2 SBR units were labeled SBR1 and SBR2. The SBR1, as a control unit, was reaerated in the prolonged idle period for 10 hours. The aerator was operated by timer which switched on at the 12th hour and switched off at the 22nd hour. The SBR2, as an experimental unit, was not reaerated in the idle period by switching off both mixer and aerator.

Unit Operation

1. Influent

Hospital wastewater from the Rajvithi Hospital wastewater was used. This was taken from the influent of the treatment plant and was filtered through fine nylon screen to eliminate suspended solids which might clog the pipeline of the experimental apparatus.

2. Experimental Strategy

The study was divided into 2 parts by controlling the MLSS concentrations at a level of 2,400-2,600 mg/L for the first part (Part I) and 1,400-1,600 mg/L for the second part (Part II).

3. Running the SBR units

A calculated amount of seed sludge was utilized to start up the system and wastewater was fed into both reactors to the working volume. Timers were set to control the SBRs to function in each period as previously described. In the draw period, supernatant was discharged by manual valve. A proper amount of sludge was drawn at the end of the second oxic period in order to keep a stable MLSS concentration in the reactors. At the beginning, the operation of the SBR system units continued until they met the steady state determined by the constant effluent of COD. Then, collection of samples for Part I was exercised consecutively for 16 days.

After the experiment of Part I was done, Part II immediately started by discharging mixed liquor out of both reactors at the end of the second oxic period to yield MLSS concentrations of 1,400-1600 mg/L. Collection of samples was conducted for 16 days in this Part II experiment as well.

4. Sample analyses

The grabbed samples of influent and effluent were analyzed for COD, BOD, TKN, and SS. The analyses followed the standard methods for the examination of water and wastewater.[4] Due to the tedious and time consuming analytical procedure for BOD, this parameter was not daily measured. The influent and effluent BOD were measured once a week, then these measured BOD and COD values from the same samples were rationed to yield the BOD values.

3. Results and discussion

The hospital wastewater used as an influent for the SBR system had the characteristics as shown in Table 1. The average concentrations of COD, BOD, TKN, and SS were 226, 113, 36 and 136 mg/L, respectively. It should be noted that this wastewater was filtered through a fine nylon screen before entering the SBR system, hence the obtained influent concentrations might be slightly less than they should have been.

The removal efficiencies of the SBR system units were analyzed and summarized as follows:

Effect of reaeration on the efficiency of SBR system

Comparisons between the SBR1 unit (with reaeration in its idle period) and the SBR2 unit (without reaeration in the same period) in removal COD, BOD, TKN, and SS were performed. The removal efficiencies were

93.4%, 97.7%, 95.7%, 98.9% for COD, BOD, TKN, and SS in SBR1 unit as compared to 91.9%, 97.2%, 95.2%, and 99% for those in the SBR2 unit (Table 1). Based on paired t-test analysis at 0.05 level of significance, the COD, BOD, and TKN removal efficiencies of SBR1 unit were found to be significantly better than those of SBR2. Whereas the SS removal efficiency was not statistically different between the 2 units. These results implied that reaeration in the prolonged idle period had an effect on the organic (COD&BOD) removal efficiency of the SBR system. The unit without reareration in the prolonged idle period resulted in an unsuitable environment, as there was less food and oxygen, for the microorganisms in the reactor for a long period. Accordingly, these bacteria had to spend time to acclimate themselves to this new environment[5] which was different from the treatment period when there was plenty of food and oxygen. Hence, the substrate utilization rates of these bacteria were less than those with reaeration. This could contribute to significantly less COD & BOD removal efficiency in the SBR unit without reaeration as compared to that with reaeration.

Effect of MLSS concentrations on the efficiency of SBR system

Comparisons among the SBR1 and SBR2 units in Part I (MLSS concentrations of 2,400-2,600 mg/L) and Part II (MLSS concentrations of 1,400-1,600 mg/L) were evaluated. The results of these four conditions were statistically analyzed (one-way ANOVA) and presented in Table 2. The COD and BOD removal efficiencies of SBR1 of Part I were significantly different from those of the other three conditions. In other words, organic removal of the unit with reaeration for MLSS concentrations of 2,400-2,600 mg/L was better than the other study conditions. The results correspond to the logic that the substrate utilization depends on the amount of bacteria.[6] Hence, the system which had more MLSS concentrations achieved the better organic removal efficiency as observed above.

However, the organic removal efficiency of the units without reaeration either with 2,400-2,600 mg/L MLSS or with 1,400-1600 mg/L MLSS was not different. Considering the F/M ratio of the system, it was higher at MLSS concentrations of 1,400-1600 mg/L than at MLSS 2,400-2,600 mg/L (F/M ratio 0.05 and 0.03 respectively). This implied that bacterial cells at MLSS concentrations of 1,400-1,600 mg/L received more sufficient food than at 2,400-2,600 mg/L MLSS concentrations. The potential of substrate decomposition of bacteria was affected by the limited food in the reactor. With F/M ratio 0.03 in the reactor, these bacteria could not grow up to the peak log-growth phase. Consequently, the substrate utilization rate was not as good as it should have been. Accordingly, the system unit without reaeration for the 2,400-2,600 mg/L MLSS concentrations could not achieve a significantly better COD& BOD removal efficiency than that of 1,400-1,600 mg/L MLSS concentrations.

In terms of TKN and SS removal efficiencies, the MLSS concentrations of 2,400-2,600 mg/L for both SBR1 and SBR2 were found to be better than the MLSS of 1,400-1,600 mg/L for SBR1 and SBR2 units. This could be explained that TKN removal efficiency depended on the amount of microorganisms, especially the nitrifying and denitrifying bacteria which were the important microorganisms for nitrogen removal. The study results were in agreement with Porntaveewat's study[2] which reported TKN and SS removal efficiencies of the SBR system better at 2,500 mg/L of MLSS than at 1,500 mg/L.

The coefficient of variation (C.V.) was utilized to determine the variability across study samples. The C.V. values less than 10% signified that the efficiency of the system unit was reliable. From this study, the C.V. values of COD, BOD, TKN, and SS removal efficiencies were all less than 10% for both SBR1 and SBR2 units of Part I and Part II. Whereas the C.V. values for the influent characteristics (11-23%) showed a large variation which is the nature of domestic wastewater. These results implied that SBR system either with or without reaeration in the prolonged idle period produced a stable removal efficiency though the influent characteristics had a large variation.

4. Conclusion

The average COD, BOD, TKN, and SS removal efficiencies of the SBR system unit without reaeration in the prolonged idle period was slightly less than that with reaeration in the same period. However, all the removal efficiencies were greater than 90%. Moreover, the effluent values (BOD, TKN, and SS) obtained from the units without reaeration also meet the building effluent standards. It could be concluded that the SBR system without reaeration produced the satisfactory removal efficiency as well as that with reaeration.

Practically, the appropriate MLSS concentrations for operating an SBR system without reaeration in the prolonged idle period should be 1,400-1,600 mg/L. Not only that it has a similar removal efficiency to the system with reaeration but it also reduces unnecessary power and energy consumption.

5. References

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Table 1 Characteristics of wastewater and removal efficiency of the SBR units

Parameter	Concentration (mg/L; $\bar{X}$±S.D.)			Removal Efficiency (%)		
	Influent	Effluent				
		SBR1	SBR2	SBR1	SBR2	P-value
COD	226±46	14±4	17±4	93.4	91.9	<001
BOD	113±21	2.5±0.8	2.9±0.8	97.7	97.2	<0.001
TKN	36±9	1.4±0.3	1.7±0.4	95.7	95.2	0.040
SS	136±28	1.4±0.6	1.2±0.6	98.9	99.0	0.055

Table 2 Removal efficiency of SBR units with respect to the effects of reaeration and MLSS concentrations.

Parameter	Unit	Removal Efficiency (%)	C.V. (%)	d.f.	F-value	P-value
COD	SBR1-Part I*	94.3	2.0	3,60	4.13	0.0099
	SBR2-Part I	92.2	3.1			
	SBR1-Part II	92.4	1.8			
	SBR2-Part II	91.6	2.4			
BOD	SBR1-Part I*	98.0	0.6	3,60	4.12	0.0101
	SBR2-Part I	97.3	1.0			
	SBR1-Part II	97.4	0.6			
	SBR2-Part II	97.1	0.7			
TKN	SBR1-Part I*	96.8	0.8	3,60	11.58	<0.0001
	SBR2-Part I*	96.2	1.3			
	SBR1-Part II	94.6	1.1			
	SBR2-Part II	94.3	1.5			
SS	SBR1-Part I*	99.1	0.3	3,60	11.58	<0.0001
	SBR2-Part I*	99.3	0.3			
	SBR1-Part II	98.6	0.3			
	SBR2-Part II	98.8	0.3			

*indicates significant differences from the other (non-asterisked) units.

Note: SBR1-Part I = unit with reaeration & 2,400-2,600 mg/L MLSS
SBR2-Part I = unit without reaeration & 2,400-2,600 mg/L MLSS
SBR1-Part II = unit with reaeration & 1,400-1,600 mg/L MLSS
SBR2-Part II = unit without reaeration & 1,400-1,600 mg/L MLSS

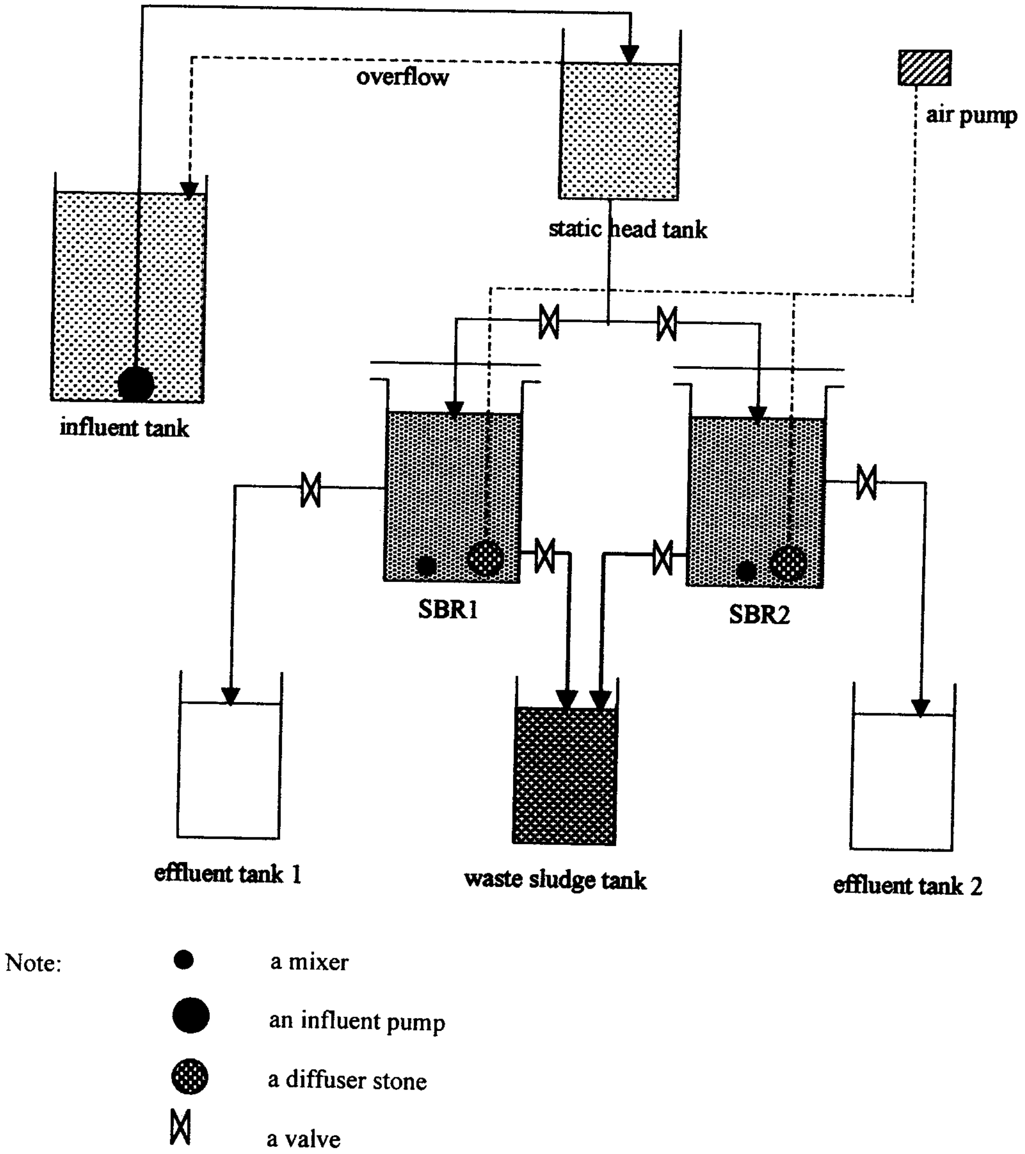

Figure 1. The schematic diagram of experimental setup