ISSN (online): 2349-6010

Performance of Sequencing Batch Biofilm Reactor on Low Filling Ratio to Treat Sewage

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Abstract

The Operational Performance of the Sequencing batch biofilm reactor (SBBR) on low filling Biomedia Ratio for treating the Sewage. The Removal efficiency of COD, BOD, TSS and Ammonical Nitrogen were investigated by using Biomedia made of PVC. The experiments were carried out at size 18×15×30 cm with working volume 5–L reactor made from Acrylic sheet. The reactor was operated as SBBR. SBBR was filled with Biomedia to 20 % of the working volume. SBBR were operated at 6h cycling period on a day that consisted of wastewater fill (3 min), reaction (5h), settling (50 min) and draw (3 min). During filling sewage aeration was off. The effect of filling ratio on SBBR performance was determined. In normal operation, average COD removal rate was calculated as 80.14 % SBBR.
Keywords: Sequencing batch biofilm reactor (SBBR), Biofilm, COD, Nitrogen removal, Wastewater treatment

I. INTRODUCTION

Increasing of strict effluent standards require more effective wastewater treatment to meet effluent limitations before discharging in to receiving water bodies [1]. Particularly in areas characterized by low or varying flow patterns, sequencing batch reactor (SBR) is being used successfully to treat both municipal and industrial wastewaters. SBR treatment system consists of a sequencing operation including the steps of fill, react, settle, decant and idle [2]. Since the same reactor is used for biological degradation and sedimentation in SBR operations, capital and operating costs are lower than conventional activated sludge processes, but it requires a higher level of control and automation.

The SBR can be combined with biofilm growth on the surface of a support material, originating the sequencing batch biofilm reactor (SBBR).

These processes use carriers which are designed to provide a protective surface to the biofilm and optimal conditions for cultivation of microorganisms when they are freely suspended in water. A higher surface area of carriers can provide more sites for microorganisms to absorb and grow.

Biofilm carriers are used for upgrading current wastewater treatment systems. Many studies regarding successful operation for new wastewater treatment plants and upgrades for existing wastewater treatment plants have been reported

The sequencing batch biofilm reactor (SBBR) system has attracted a great deal of attention due to its ability to take the advantages of both a biofilm reactor and an SBR. In pure biofilm reactors the biomass grows only on carriers, whereas in SBBRs, both biofilm and suspended activated sludge are in the same tank. In the SBBRs, the biomass grows as a biofilm on small plastic carriers that move freely into the wastewater.

Many studies have been performed by modifying the typical SBR to provide high surface area for biofilm growth. SBBRs have already been used in the treatment of domestic wastewater [3–6], dairy wastewater [7,8], textile wastewater [9], tannery wastewater [10], leachate [11] and for nutrient removal [12–16]. Pollutant removal efficiency of the SBBR is much higher than conventional SBR.

In most experiments, synthetic wastewater was used because it allows easy process control. The aim of this study was to evaluate the operational suitability and efficiency of the SBBR on low filling ratio to treat sewage. The performance of SBBR was investigated by the removal efficiency of COD, BOD, TSS and Ammonical nitrogen.

II. MATERIALS AND METHODS

A. Lab-Scale Reactor and Wastewater:

The experiments were carried out in lab-scale reactor; the SBBR as illustrated in Fig. 1. One 18×15×30 cm size with working volume 5–L reactor was made from Acrylic sheet. The reactor was operated as SBBR. SBBR was filled with the biomedia 20% of the working volume. Compressed air was supplied via diffusers at the bottom of the reactors. Mixing was performed inside the reactor by a mechanical stirrer. The dissolved oxygen (DO) concentrations were maintained above 3mg/L in the SBBR.

Experiments were conducted at room temperature. Rusten et al. reported that the minimum DO concentration was maintained 3mg/L throughout the experimental set up to preserve the biofilm under appropriate conditions [17].

Activated sludge was obtained from a local municipal WWTP as a seeding material to the reactor. Wastewater was fed and discharged by means of the Bernoulli's principle. The procedures of the reactor operation, such as feeding, aerating, settling and withdrawing, were controlled time to time by manually.

In experiments, the wastewater samples were collected from pumping station, Ichchanath, Surat. The main characteristics of the Pumping station Raw Sewage are given in Table 1

Table - 1
Composition of Average Values of Sewage at Pumping Station

Parameter	*Unit*	*Average values*
COD	*mg/L*	*288.25 ± 95*
BOD_5	*mg/L*	*103.44 ± 31.55*
TSS	*mg/L*	*268.91 ± 50.83*
Ammonical Nitroge	*mg/L*	*5.29 ± 3.61*
TKN	*mg/L*	*35.04 ± 13.12*
pH	–	*7.74 ± 0.16*

B. Carriers:

The Kaldnes K1 biofilm carrier elements are made of Virgin polyethene and are shaped like small cylinders (a nominal diameter of 12mm and a nominal length of 9mm) with a cross inside the cylinder and longitudinal fins on the outside. The Kaldnes carriers have a specific biofilm protected surface area of 550m2/m3 bulk volume of carriers. The Kaldnes biofilm carrier element is illustrated in Fig. 2.

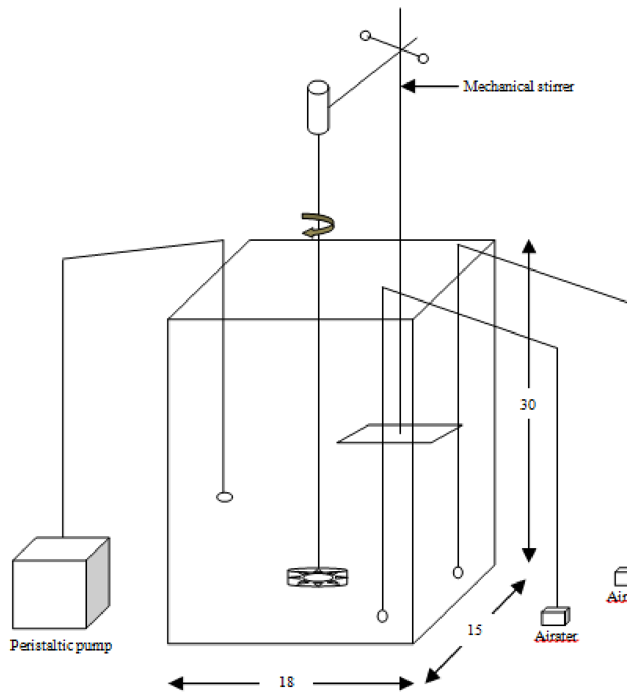

Fig. 1: Lab-Scale Reactor

Microscopy of the biofilm media from several pilot and full-scale moving bed biofilm plants has shown no sign of biofilm growth on the outside of the smooth plastic elements. The reason is believed to be the erosion caused by the frequent collisions between the pieces. Therefore, the biofilm surface area has been calculated based on the internal (protected) surface of the plastic elements [18]


Fig. 2: Kaldnes Biofilm Carrier

The available surface area (referred to the reactor volume) was changed according to filling ratio. Protected surface is calculated as 110m2/m3 for filling ratio of 20%.

C. Experimental Procedure:

SBBR were operated at 6h cycling periods on a day that consisted of wastewater fill (3 min), reaction (5h), settling (50 min) and draw (3 min).

In the settling phase, the aeration and mixing were stopped and the mixed liquor was left to settle for 1h. The supernatant (3L) was removed and the remainder was used for the next cycle in SBBR.

A start-up period of about 4weeks for biofilm growth on the carrier was followed by 1week of testing period in SBBR. The SBBR were operated for a period of 1week to confirm the maturity of the biological treatment systems and to ensure that the steady state conditions were achieved. Steady state condition is defined as the period during which the effluent quality was relatively constant with regard to the parameters of COD and TSS.

D. Analytical Methods:

All samples were analysed for COD, TSS, BOD5 and Ammonical nitrogen. The analytical methods were carried out as dictated by the standard methods.

The amount of biomass in the system is extremely important for treatment. In each experiment, the concentration of both attached and suspended biomass was measured as MLSS and MLVSS. Each day, 40mL of mixed liquor was removed from the reactor to adjustment of the sludge age in SBBR. But, mixed liquor cannot be set as a constant in SBBR because of the excessive biofilm which could not be removed from the reactor.

III. RESULT AND DISCUSSION

A. Normal Operation:

SBBR was fed with the sewage collected from pumping station, Ichchanath, surat. The samples were studied for COD, BOD, TSS and Ammonical nitrogen removal rates. COD removal rate and TSS removal rate were very high during the operation of reactor. Observation for the Influent COD concentration was from 224 to 360mg/L, BOD concentration was from 83 to 124mg/L, TSS concentration changed between 148.99 and 370mg/L, Ammonical nitrogen concentration changed between 4.48 to 7.28mg/L. Their average Influent values were 287.73±72.27, 99.71±24.29, 257.52±112 and 5.75±1.53mg/L for COD, BOD, TSS and Ammonical nitrogen respectively. Fig. 3,4,5,6 shows that effluent COD, TSS, BOD and Ammonical nitrogen profiles in operation for SBBR.

Martin–Pascual et al. studied that the removal at organic matter was significantly low when the media filling ratio was low [20]. In our study, although some decrease was observed, it did not play an important role for the COD removal

According to Matos et al. The 80% biomass was observed at attached growth 20% was as suspended growth[21]. In present study influent MLSS & MLVSS were 3300 mg/L & 2488 mg/L.

Rodgers et al. in his study operated a laboratory scale reported SBBR in an 8h cycle, which was the COD and suspended solids removals reported were 95% and 93%, respectively. [22]

Fig. 3 shows that Influent and effluent COD profile in operation SBBR. Average effluents of COD concentration were 43.23±20 for SBBR.

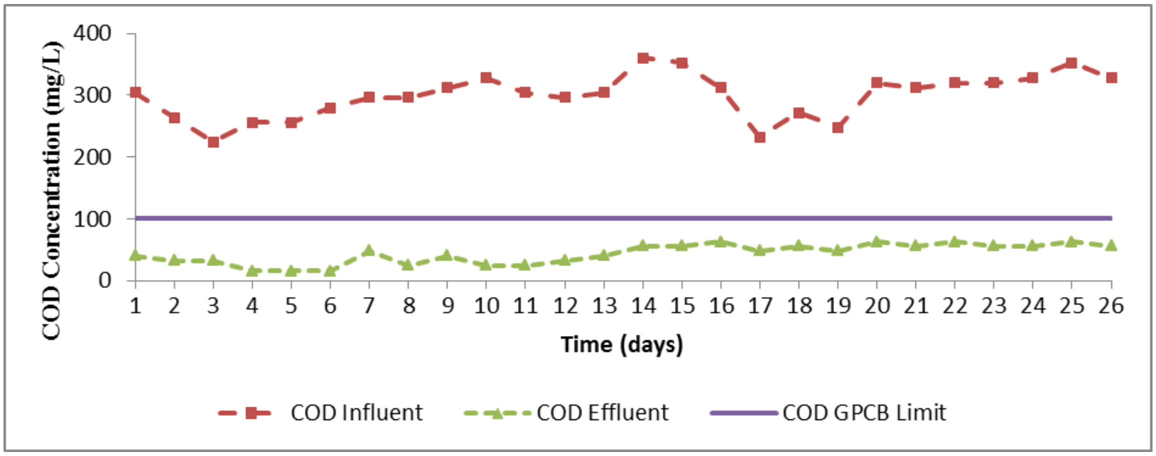

Fig. 3: COD Removal Rates during the Operation for Reactor

F/M ratio can be controlled by the wasting of biological growth. But, in this study, instead of controlling F/M ratio, its observed value was calculated for reactor. The reactor had certain amount of biomass, which led to different F/M ratio in operation. TSS in wastewater can be treated using physical treatment methods up to 60–70%. Because there is no primary settling tank, SBR is loaded higher than the conventional activated sludge systems in terms of solid loadings. However, 95% TSS removal efficiency can be obtained in sewage treatment by using SBR [19].

Fig. 4 shows that influent & effluent TSS profile in operation SBBR. Average TSS removal rate was 97.27%. Average effluents of TSS concentration were 7.45 for SBBR.

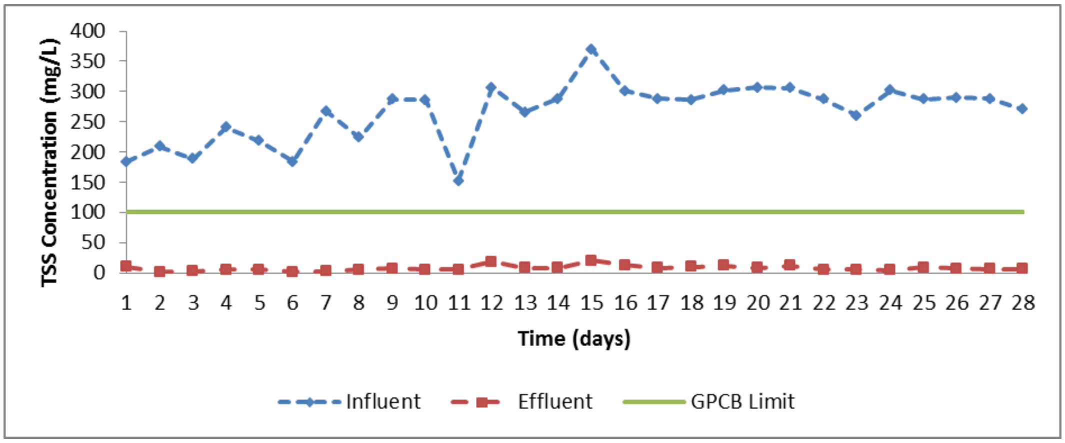

Fig. 4: TSS Removal Rates During the Operation for Reactor

Fig. 5 shows that effluent BOD profile in operation SBBR. The average BOD removal rate was 82.72%. Average effluents of BOD concentration were 17.41±6.83 for SBBR.

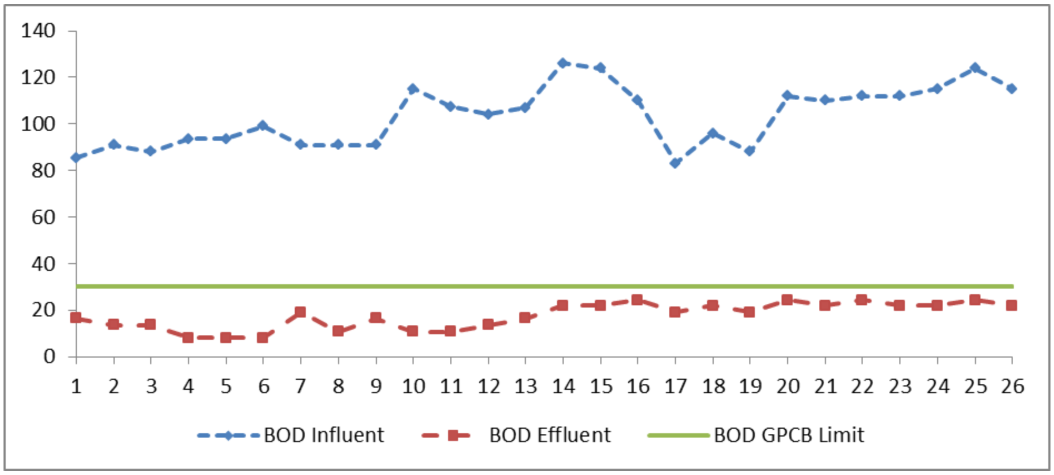

Fig. 5: BOD Removal Rates During the Operation for Reactor

Fig. 6 shows that influent & effluent Ammonical nitrogen profile in operation SBBR. The average Ammonical nitrogen removal rate was 67.8%. Average effluents of Ammonical nitrogen concentration were 1.27±0.41.

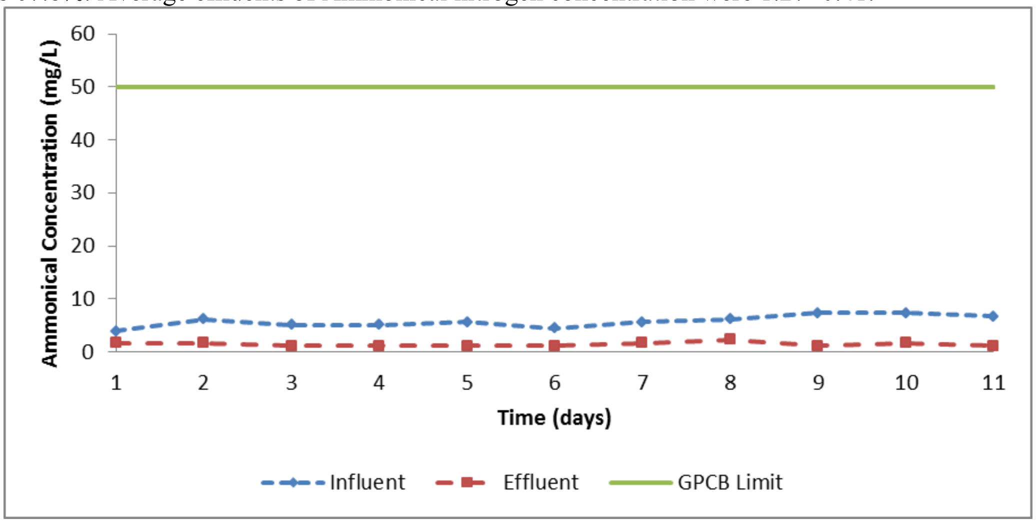

Fig. 6: Ammonical Nitrogen Removal Rates During the Operation

IV. CONCLUSION

The SBBR was designed to provide a compact and cost-effective treatment solution for wastewater. For 5-week period, the plant was operated under normal operating conditions its influence on small-scale treatment systems. According to the amount of biomass, better effluents were obtained. As the interruption increased, recovery took more time to reach steady state conditions for the reactors. Accordigly low filling ratio of media it effluent concentration was below the GPCB limit. The results show that SBBR is superior to SBR due to better process performance as COD, BOD, TSS and Ammonical nitrogen removal.

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