A Novel Approach for treatment of Urban Wastewater by Sequential Batch Biofilm Reactor (SBBR)

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Abstract: With the introduction of the stringent standard by pollution control board, it is our responsibility to treat the sewage to comply the standards of receiving streams. We are aware of the suspended growth process like Activated Sludge Process (ASP) and Sequential Batch Reactor (SBR) and attached growth process like Moving Bed Biofilm Reactor (MBBR). Nowadays a new trend is developed to adopt the combination of suspended and attached growth process for wastewater treatment. In SBR, four processes fill, aeration, settling and decanting take place with certain retention time where microorganisms are present in suspended form. In MBBR, microorganism's growth take place on the PVC media in aeration tank and secondary settling take place in another tank with certain retention time. So the present study will show the feasibility of Sequential Bed Biofilm Reactor (SBBR) with combined suspended and attached growth system for the treatment of domestic sewage. Compared with an SBR and MBBR, SBBR has many advantages, such as more biomass and higher removal efficiency, less sludge and sludge conglomeration, greater volumetric loads and increased process stability toward shock loadings. The main advantage of SBBR compare to SBR and MBBR is higher nutrient removal efficiency in the context of nitrogen and phosphorus removal. The study will show COD, BOD, TKN and TSS parameter with different detention time and organic loading. Domestic sewage flowing through the SBBR will receive the extensive treatment with least consumption of energy.

Keywords: Sequential Batch Reactor(SBR); Moving Bed Biofilm Reactor(MBBR); Nutrient Removal; Sequential Batch Biofilm Reactor(SBBR); PVC media

I. Introduction:

Wastewater treatment is becoming crucial day by day due to increasing the wastewater generation in city due population explosion. Growth of urbanization in India is at rapid rate. As per the WATER (PREVENTION AND CONTROL OF POLLUTION) ACT, 1974 "Sewage Effluent" means effluent from any sewerage system or sewage disposal works and includes sullage from open drains. In India, most of the cities have conventional sewage treatment plant (ASP based) and ASP based treatment plant's BOD removal efficiency is 60-70%, COD removal efficiency is 55-65 % and Ammonical Nitrogen removal is 10-20 %*. Whereas modern technologies like SBR and MBBR can overcome these challenges [10]. We are striving for the solutions where domestic sewage treatment can become more advance.

II. Literature Survey:

Koul, A., John, S.(2015), The average removal percentages of BOD were 88.58% and 79.32% for SBR and MBBR respectively. The average removal percentages were 71.75% and 74.36% for SBR and MBBR respectively. In the present study, the BOD removal efficiency varied in the order SBR > MBBR. The COD removal was in the order MBBR > SBR. The TSS removal efficiency followed the order MBBR > SBR. The nitrates removal efficiency was in the order MBBR > SBR [7]. If COD removal is achieved more in MBBR and BOD removal is achieved more in SBR then why we should not go for the combinations of the two systems?

Rajput, D. C., Khambete, A. K.(2015), The laborator scale SBBR with the cycle time 8 hour, which was the COD and suspended solids removal reported were 95% and 93%, respectively. Average COD concentration is 28.53±20 for SBBR. The average BOD removal rate was 87.22%. Average effluents of BOD concentration were 12.33±6.73 for SBBR. The average Ammonical nitrogen removal rate was 67.8%. Average effluents of Ammonical nitrogen concentration were 1.27±0.41 [12].

Hanh Van N., Phong Tan N.(2013), A sequencing batch moving bed biofilm reactor (SBMBBR) system on 5 steps using K3 media with surface area is 175 m^2/m^3 increases effectiveness compared to traditional sequencing batch reactor (SBR) system on fishery wastewater treatment. The COD, TKN and TP removal efficiency under the last organic loading of 2000 ± 40.4 g COD/m^3.d were 94.6 ± 0.2%, 53.4 ± 3.9%, 50.0 ± 3.2% and 89.8 ± 2.5 mg/l, 92.7 ± 0.9 mg/l, 12.5 ± 0.5 mg/l. The TKN removal of SBMBBR was higher than SBR because of the following reasons: the total bio-sludge mass was increased the quantity in the attached bio-sludge in the surface of media, this attached microbial growth provided increased rates of waste degradation and removal, and thought to be particularly well suited for increasing rates of ammonia conversion to nitrate (nitrification) [5].

Sirianuntapiboon, S., Yommee, S.(2006), The moving bio-film (MB) might be applied in the conventional-aerobic-SBR to increase the amount and quality of bio-sludge of the system resulting in improvement of the effluent quality and system efficiency. In this study, a new type of MB was applied into the conventional-aerobic-SBR. The efficiency and bio-sludge quality of the system was determined under various organic loading and HRT operations to compare with conventional-aerobic-SBR. BOD5 and TKN removal efficiencies of the MB-aerobic-SBR were about 10–20% higher than the conventional-aerobic SBR, respectively [13].

Gulhane, M. L., Kotanjale, A. J.(2014), Hybrid Moving Bed Biofilm Reactor working in combination with Attached and Suspended Growth Reactor will provide the better results as compared to normal Moving Bed Biofilm Reactor. Higher efficiency in terms of BOD and COD removal is expected when the domestic wastewater will be treated in combination of treatments [4].

III. Materials and Methods

A. Pilot scale reactor

The experiments were carried out in lab-scale reactor; the SBBR as illustrated in Fig. 1. Reactor is made up of 2mm thickness Mild Steel(MS) sheet. The design of SBBR is done with the basic principles of the SBR and MBBR. The capacity of reactor is 300 L/day. The reactor was operated as SBBR. SBBR was filled with the biomedia 25% of the working volume [5]. Compressed air was supplied via diffusers at the bottom of the SBBR reactor. Mixing was performed in separate anoxic provided in the system. This SBBR system is working with the pre-anoxic system because its required carbon source to convert nitrate into nitrogen gas for efficient removal of Total Nitrogen from the wastewater.

The dissolved oxygen (DO) concentrations were maintained above 3mg/L in the SBBR. Experiments were conducted at room temperature. Minimum DO concentration was maintained 2-3mg/L throughout the pilot scale set up to maintain the biofilm under appropriate conditions [12].

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 decanting, were controlled time to time by manually.

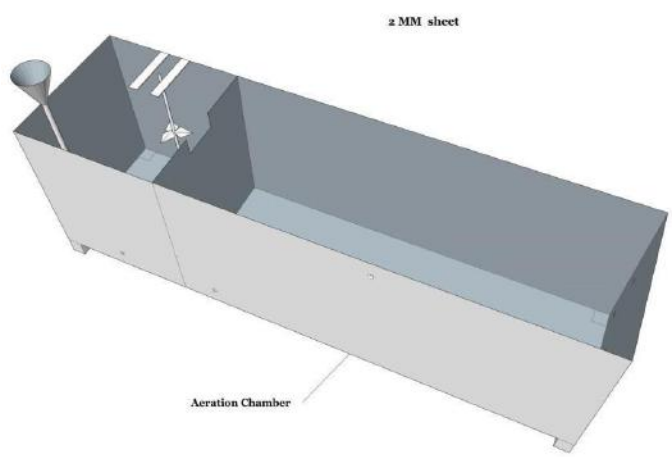

Fig. 1- SBBR Reactor

Fig. 2- PVC media

There are two chambers in reactor: Anoxic and Aerobic. First wastewater passes through the anoxic chamber where incoming wastewater carbon reacts with the nitrate and that converts into nitrogen gas. PVC virgin plastic media is used with 400 m^2/m^3 surface area.

B. Experimental Procedure

In this study, Cycle is set for 6 hour. Filling(10 minute), Aeration(4 hour), Settling(1 hour and 30 minute), Decanting(5 minute), Recycle to Anoxic tank for reaction by manually(15 minute).

In the initial setup period reactor has worked 3 weeks for commissioning phase. Results were taken after the steady state condition is achieved.

C. Analytical Methods

All samples were analysed for COD, BOD_3 and Total Kjeldalh Nitrogen. The analytical methods were carried out as dictated by the APHA standard methods. In each experiment, the concentration of both attached and suspended biomass was measured as MLSS.

IV. Pilot scale set up of SBBR

V. Results and Discussion

Present study deals with the raw sewage with the preliminary treatment in grit chamber. Fig. 3 shows that effluent BOD profile in operation SBBR. Average influent COD concentration is 383± 40 mg/L. The COD removal efficiency was 89±3 %.

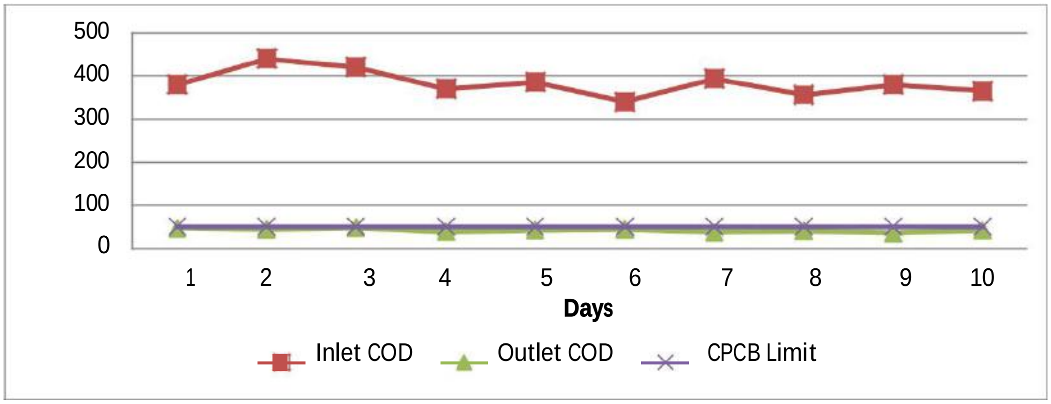

Fig. 3- COD removal during SBBR operation

Fig. 4 shows that effluent BOD profile in operation SBBR. The influent BOD concentration is 135±15 mg/L and BOD removal efficiency was 92±2 % achieved during the normal operation of SBBR.

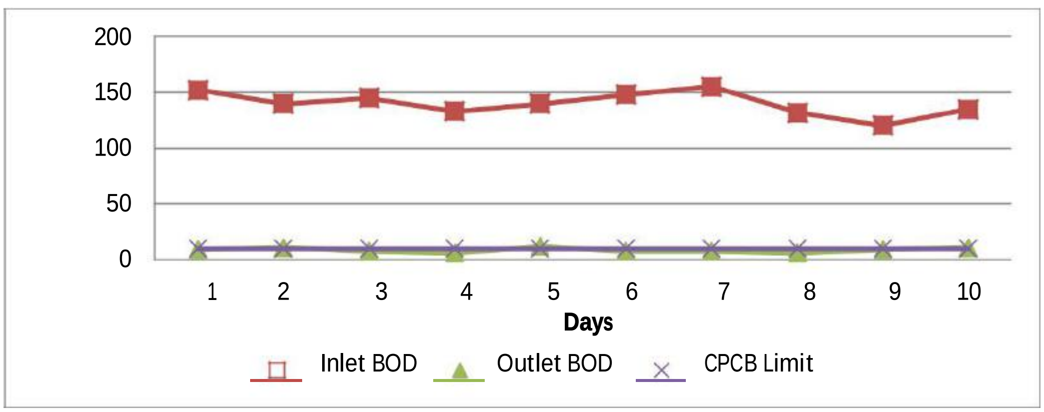

Fig. 4- BOD removal during SBBR operation

Fig. 5 shows that effluent TKN profile in operation SBBR. The influent TKN concentration is 25±5 mg/L and TKN removal efficiency was 65±10 % achieved during the SBBR operation.

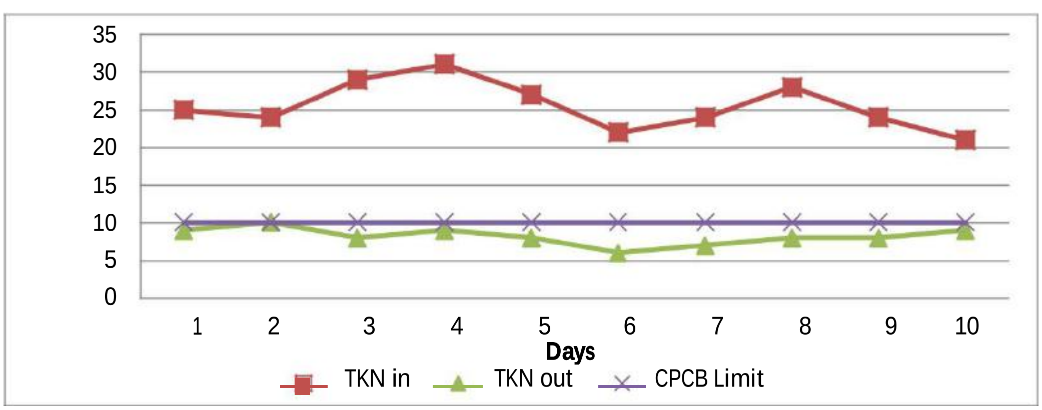

Fig. 5- TKN removal during SBBR operation

Fig. 6 shows that MLSS profile in operation SBBR. After 4 weeks of commissioning of the SBBR reactor MLSS concentration is achieved 2492.5±200 mg/L.

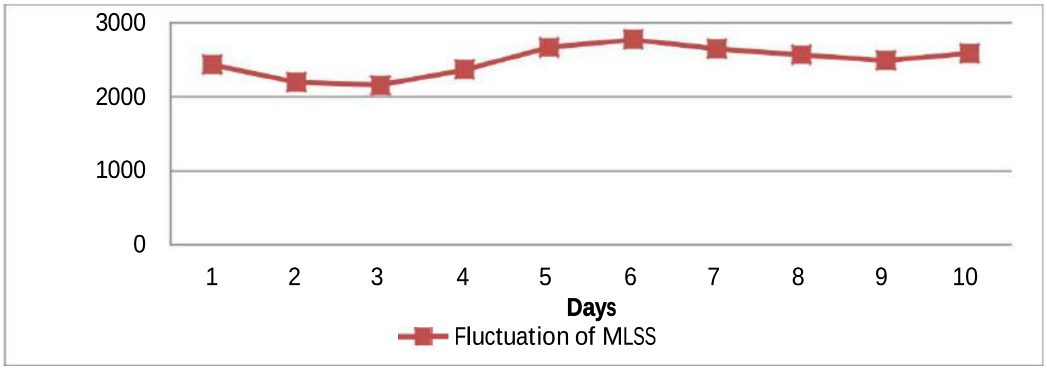

Fig. 6- MLSS profile during the study period

VI. Conclusion

The SBBR was designed to provide a compact and cost-effective treatment solution for wastewater compare to SBR and MBBR. The small scale 300 L/day SBBR prototype is working efficiently as the results showed in the paper. As the wastewater characteristics varied, recovery took more time to reach steady state conditions for the SBBR. The MLSS variation is occurred due to variation in influent characteristics. The results show that SBBR is working better compare to SBR and MBBR due to better process performance as COD, BOD, and TKN removal.

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