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Performance Evaluation of Moving Bed Bio-Film Reactor (MBBR) for Treatment of Domestic Wastewater

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Abstract: ***The moving bed bio-film reactor (MBBR) is the promising technology for the biological treatment of domestic as well as the industrial wastewater. Interestingly, the technology has the considerable scope to reduce the operation and maintenance cost with better efficiency. The attached growth system is suitable for the treatment of domestic wastewater which is rich source of organic matter as well as nutrients in the form of nitrate and phosphate. The attached bio-film is responsible for the biodegradation of the organic matter which remains in continuous suspension form under the aerobic condition. The subsidiary carrier filling rate and higher wastewater flow rate is responsible for the detachment of bio-film formed on the carriers. The present study was aimed to enhance the performance of reactor while treating the domestic wastewater. The continuous flow reactor is operated at constant organic loading rate and carrier filling rate with varying HRT. The experiments carried out for the varying HRT range of 24 hrs and 48 hrs shows varying BOD and COD removal efficiencies up to 90% and 95% respectively. Also, the TSS and TDS removal efficiency is seen up to 65% and 40% respectively.***

Keywords: Domestic Wastewater, MBBR, HRT, COD, BOD, TSS, TDS

1. Introduction

Nowadays, water has become the major issue faced by the each and every part of the world [2]. To overcome the issue it is necessary to treat the domestic wastewater which is rich source of organic waste as well as the nutrients in the form of nitrate and phosphate [9]. In India, it is estimated that there is an immense difference between the production of domestic wastewater and the treatment of generated domestic wastewater. The direct discharge of domestic wastewater into the natural water bodies may lead to the water pollution which has various obstructive impacts on the environment and aquatic life. Due to which the greater and adverse impact on the water sources is increased. To demolish these problems, the treatment of domestic wastewater is must and its reuse for the domestic as well as agriculture purpose can become an eco-friendly solution for the conservation of water [2]. The central pollution control board (CPCB) has fixed the specified norms considering various factors before discharging the wastewater in to the any natural bodies i.e. water and land. So, it is mandatory to remove the contaminants by providing chemical treatment or biological treatment methods. The biological wastewater treatment methods are economically suitable in the developing countries which have low operation and maintenance cost with better efficiency than any other treatment methods [9].

Moving bed bio-film reactor (MBBR) is widely applied technology used to treat not only the domestic wastewater but also the industrial wastewater [3]. The process incorporates the better efficiency to treat the wastewater ranging from lower concentration to the higher concentration [4]. The MBBR technique has various advantages over any other biological treatment methods used to treat wastewater [3]. MBBR has the positive aspect of both the suspended growth and attached growth [5]. The MBBR technique has the combined advantage of both activated sludge processes and any other bio-film reactor [8]. In this process, carriers are used for the adhesion of microbial bio-film on surface of carriers which is responsible for the biodegradation of organic matter in wastewater [10]. The continuous suspension of carriers in reactor is maintained by providing the aeration system which introduces the fine or medium sized bubble into the reactor [1]. The use of attached instead of suspended biomass allows the construction of very compact reactors and provides an easier separation of bio-solids from the treated effluent [7]. The surface loading rate is responsible for the design of operational reactor [7]. The MBBR system is characterised by low suspended solid content [7]. Different size and shape of carriers have different potential to form the bio-film [1]. It is proved that the bio-film process is reliable for the elimination of chemical oxygen demand (COD) as well as the nutrient removal.

In this research study, a continuous flow MBBR system is applied to remove chemical oxygen demand (COD) and nutrient in the form of nitrate and phosphate from the domestic wastewater. The desired objective of this study is to investigate the reactor performance with respect to the HRT, i.e. 24 hrs and 48 hrs.

2. Materials and Methods

The pilot scale experimental set-up was used to treat the domestic wastewater. The treatment process consists of the primary treatment which was used to remove the suspended solids and oil and grease from the domestic wastewater which may become the barrier while biological treatment of domestic wastewater. The effluent is sent to the biological treatment unit after the primary treatment by using the peristaltic pump. The following figure shows schematic of MBBR reactor (Figure 2.1).

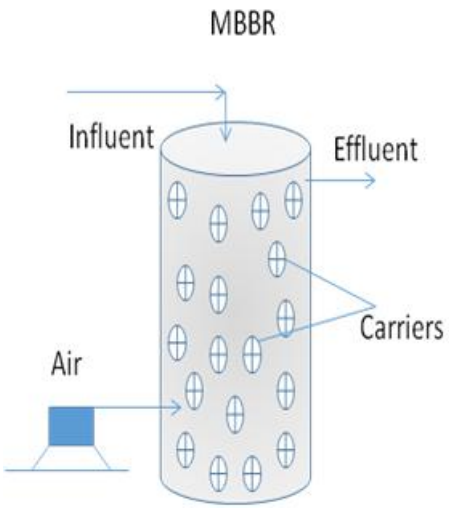

Figure 2.1: MBBR reactor with components

The continuous flowing pilot plant was kept in operation with the varying flow rate to maintain desired HRT of 24 hrs and 48 hrs. The constant carrier filling rate of 30% was maintained under the mesophilic conditions (temperature ranges between 11°C to 35°C). The pH was ranging between 6 and 8. The domestic wastewater has a lower COD/BOD ratio of 2 to 3 (higher rate of biodegradability). The figure shows carriers used in reactor (Figure 2.2).

Figure 2.2: Carrier

The plant was monitored up to 60 days analysing the main parameters (BOD, COD, pH, TSS, TDS and temperature), according to the standard protocols directed by the APHA 2005, for water and wastewater examinations [6].

The adhered biomass was evaluated by means of quantification of suspended solid concentration (APHA, 2005) [6]. Five carriers were picked randomly from the reactor. The carriers with attached biomass were kept in known amount of distilled water. The carriers were sonicated for 30 minutes in the ultrasonic sonicator to remove the attached biomass. After that, the water is passed through the filter paper and evaluated as per the standard protocol. Following figure shows adhere biomass to the carriers (Figure 2.3).

Figure 2.3: Carriers with adhered biomass

3. Results and Discussion

The performance evaluation of the MBBR was studied for the different HRT values i.e. 24 hrs and 48 hrs. While evaluating the performance the various analysed parameters are BOD, COD, TSS, TDS etc.

3.1Biochemical Oxygen Demand

The micro-organisms present in the wastewater uses the atmospheric oxygen for their survival. The lack of oxygen leads to the decrease in the removal efficiency. The BOD removal efficiencies under constant aeration flow rate for the retention time of 24 hrs and 48 hrs is seen up to 86% and 90% respectively. The BOD removal efficiency is shown as below (Figure 3.1).

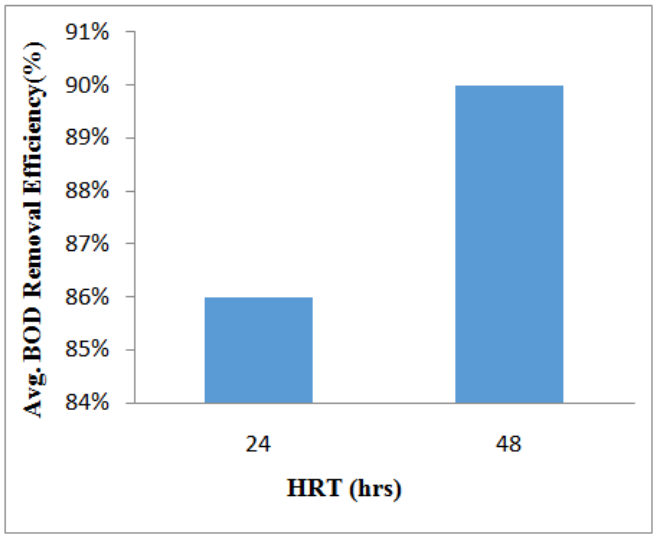

Figure 3.1: BOD removal efficiency

3.2 Chemical Oxygen Demand

Also, the atmospheric oxygen is responsible for the degradation of organic as well as the inorganic matter present in the wastewater. The COD removal efficiencies found for the HRT values 24 hrs and 48 hrs are 94% and 96% respectively. COD removal efficiency shown in (Figure 3.2).

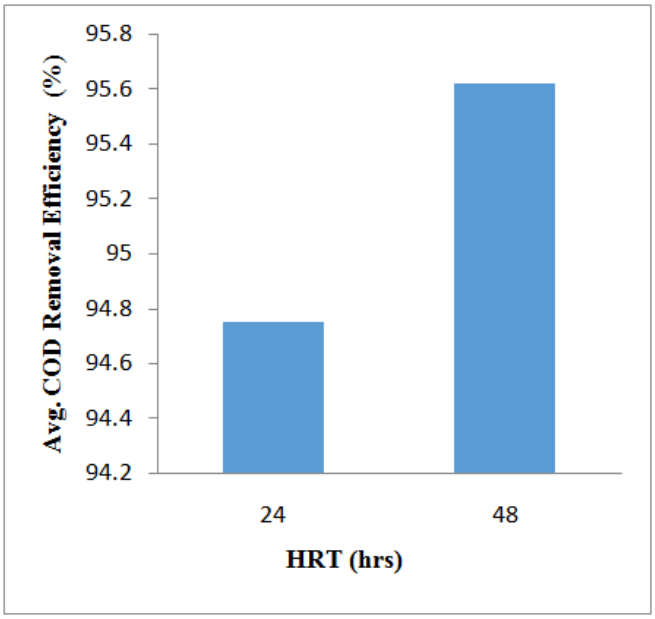

Figure 3.2: COD removal efficiency

3.3 Total Suspended Solids

The presence of large amount of suspended particles in the wastewater obstructs the penetration of atmospheric oxygen into the wastewater. The deficiency of oxygen minimizes the removal efficiency of wastewater. The obtained efficiencies for the HRT values 24 hrs and 48 hrs are 60% and 65% respectively. TSS removal efficiency shown in (Figure 3.3).

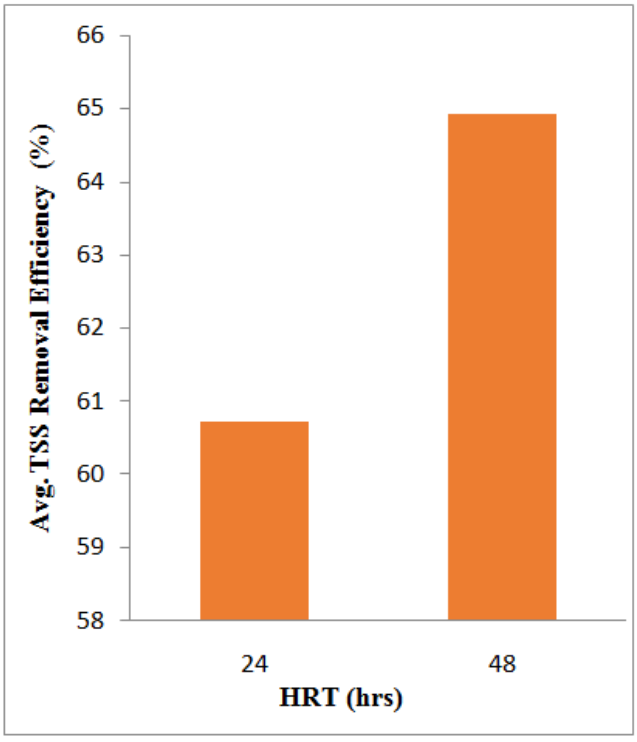

Figure 3.3: TSS removal efficiency

3.4 Total Dissolved Solids

The dissolved contaminants have great impact on the removal efficiency of reactor. The removal efficiencies got for the HRT values are 37% and 46% respectively. TDS removal efficiency is as shown below (Figure 3.4).

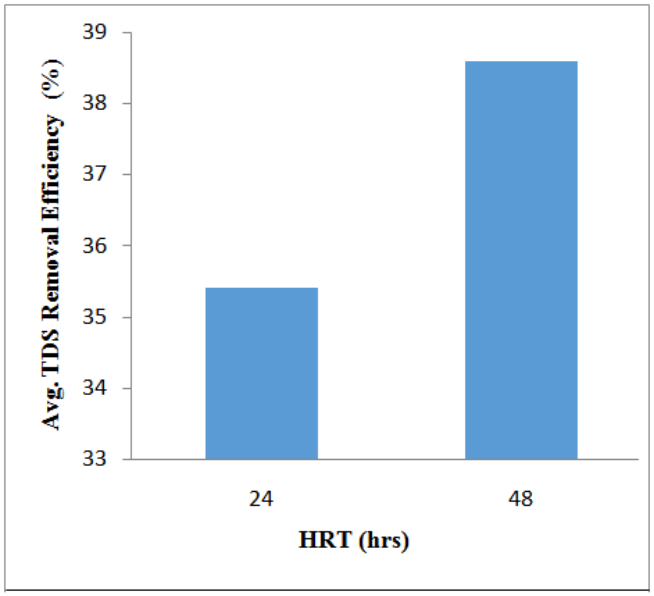

Figure 3.4: TDS removal efficiency

4. Conclusion

The research study enlight the performance of MBBR reactor under various conditions. Various parameters are studied to achieve the desired objectives suggested as per the standards. It is seen that the HRT has the greater impact on the cost of operation as well as maintenance. The carrier circulation is affected due to flow rate. As retention time decreases the flow rate increases which lead to rapid circulation of carriers. The study mainly focussing on the hydraulic retention time (HRT) for performance evaluation under mesophilic condition and constant carrier filling rate concludes:

1. The MBBR technique is suitable for the COD and BOD removal efficiently.
2. The post treatment is necessary to remove the suspended solids and dissolved solids effectively.
3. The provided carrier filling rate is suitable for the treatment of domestic wastewater.
4. It is environment friendly technique.
5. The mesophilic condition (temperature range between 10° C to 35°C) is suitable for the domestic wastewater treatment.

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