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Treatment of slaughterhouse wastewater in lab scale MBBR

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Abstract— *This research project seeks to comprehensively determine every aspect of processing slaughterhouse wastewater in a laboratory scale Moving Bed Biofilm Reactor (MBBR).Slaughterhouse wastewater is known to have high organic and ammonia concentrations, which require biological treatment before being released. Compared to chemical treatment, the MBBR process is more economical with lower sludge production. The Plexiglass reactor with a working capacity of 4.864 L and total volume of 5.632 L. The length, breadth and height of MBBR are 160 mm,160mm and 190 mm respectively was operated in batch mode with intermittent aeration for 24 hours. The HDPE carriers, which comprised about 67% of the reactor volume, were employed to support biofilm growth. Each cycle treated 1.25 L of wastewater at a 30% filling level. The treatment process achieved removal efficiencies of 85.25% COD, 86.75% BOD, and 98% NH_3-N. The results of this study validate the efficiency and effectiveness of MBBR technology for the treatment of slaughterhouse wastewater.*

***Keywords*—Moving Bed Biofilm Reactor (MBBR), Biological treatment, Biochemical oxygen Demand (BOD), Chemical oxygen Demand (COD), Biofilm Carriers (HDPE), Ammonia Nitrogen, Wastewater treatment efficiency**

1. INTRODUCTION

The high organic concentration in slaughterhouse wastewater is determined by the meat-processing procedures. If left untreated and discharged into water bodies, it will result in a serious of environmental problems, dissolved oxygen depletion of receiving water overlies, along with difficulties for public health (1,2). With the development of meat industry and rural stoppage, the treatment for slaughterhouse effluent is gradually becoming a major problem confronted by environment (3).

Biological treatment processes are generally preferred over chemical methods due to lower operational costs and reduced sludge generation (4). Among advanced biological systems, the Moving Bed Biofilm Reactor (MBBR) has gained significant attention because it combines the advantages of attached and suspended growth processes. The use of biofilm carriers enhances biomass retention, improves treatment efficiency, and provides stable performance under variable loading conditions (5). Therefore, MBBR is considered an efficient and sustainable technology for the treatment of slaughterhouse wastewater (6).

Table 1.1: Studied Bio-carriers detail

Model	PE-05	PE-10
Spec	Ø 25*10 mm	Ø 25*4 mm
Surface area	>600 m^2/m^3	>1200 m^2/m^3
Density	0.94-0.97 g/cm^3	0.94-0.97 g/cm^3
Material	HDPE	HDPE
Life Span	>15 years	>15 years
Media Fill Range (%)	15-65	15-65

Fig.1.1:(a) **MODEL PE-05**

Fig.1.2:(b) **MODEL PE-10**

2. METHODOLOGY

A laboratory-scale Moving Bed Biofilm Reactor (MBBR) fabricated from Plexiglass was employed for the treatment of slaughterhouse wastewater. The reactor had a total capacity of 5.632 L with an effective working volume of 4.864 L. capacity of 4.864 L and total volume of 5.632L. The length, breadth and height of MBBR are 160 mm,160mm and 190 mm respectively.

High-density polyethylene (HDPE) biofilm carriers, occupying approximately 67% of the working volume, were introduced to facilitate attached microbial growth and enhance biomass retention (7).

The reactor was operated in batch mode with intermittent aeration for a hydraulic retention time (HRT) of 24 hours. For each experimental cycle, 1.25 L of raw slaughterhouse wastewater was fed into the reactor at a 30% filling ratio. Aeration was supplied through diffusers to maintain adequate dissolved oxygen levels for aerobic biodegradation.

Influent and effluent samples were collected and analyzed for important physicochemical parameters such as Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), and Ammonia Nitrogen (NH_3-N) using standard procedures. The performance of the treatment processes was assessed in terms of percentage removal efficiencies of the chosen parameters.

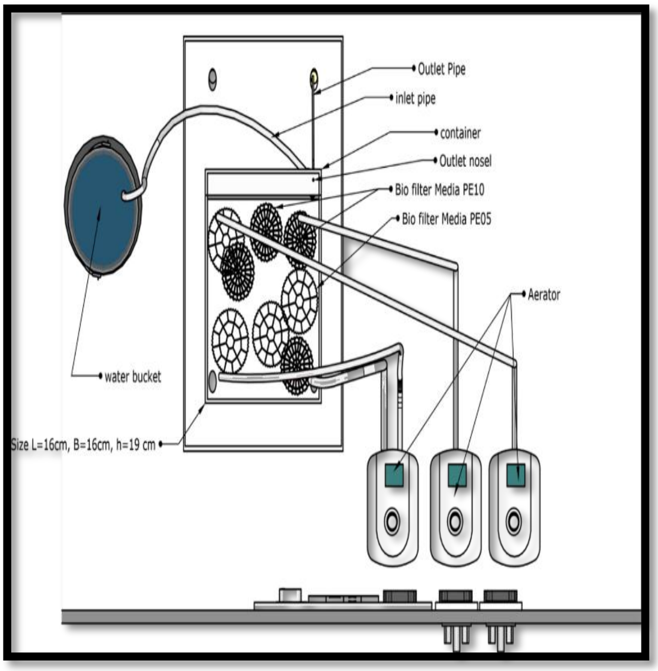

Fig. 2.1: Line diagram of lab scale MBBR

Fig.2.2: (a) Diffuser performance testing

Fig. 2.3: (b) Reactor during treatment

3. RESULTS AND DISCUSSION

The present study deals with the combined treatment of real SWW using MBBR. The secondary treatment of screen with digested laboratory scale MBBR. The reactor was seeded with digested sludge obtained from AI dua slaughterhouse. The raw wastewater had varying COD concentrations ranging from 1500-2000 mg/l.

3.1 Performance of MBBR Reactor for Organic Matter Removal

The performance of the MBBR reactor was assessed mainly based on the COD and BOD_5 removal efficiency. Figure 3.1 shows the changes in the influent and effluent COD concentrations over time.

During the startup stage, the effluent COD concentration was higher because of the acclimatization of microorganisms. But as the operational time increased, a steady reduction in the effluent COD concentration was noticed. The influent COD concentration varied between 1400 mg/L and 1600 mg/L, whereas the effluent COD concentration reduced from around 1500 mg/L to 238 mg/L, indicating an average COD removal efficiency of 75 85%.

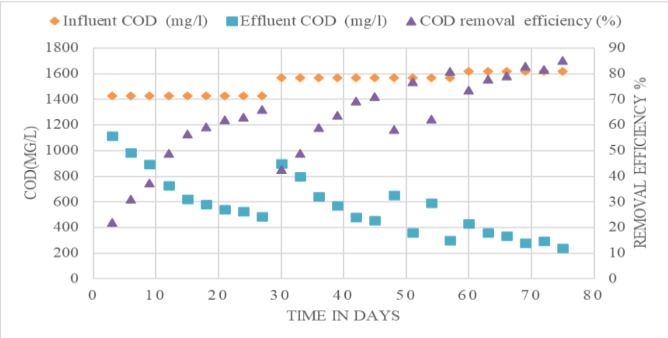

Fig. 3.1: Graph of influent and effluent COD vs Time

3.2 BOD_5 Removal Efficiency

Figure 3.2 shows the influent and effluent BOD_5 concentration over the period of study. The influent BOD_5 concentration ranged from 1000 to 900 mg/L, while the effluent BOD_5 concentration decreased steadily to around 125 mg/L at steady state.

The MBBR reactor had an average BOD_5 removal efficiency of 80-88%, which indicates efficient biodegradation of readily biodegradable organic substances. The substantial decrease in BOD_5 concentration compared to the COD concentration indicates a preference for the utilization of easily degradable substances during anaerobic treatment.

Although the removal efficiency was substantial, the final effluent BOD_5 concentration exceeded normal discharge standards, which indicates the necessity for aerobic post-treatment (8).

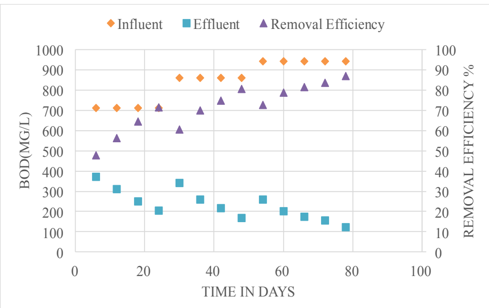

Fig. 3.2: Graph showing variation of influent and effluent BOD with time

3.3 MLSS and MLVSS Variation in MBBR

The variation of Mixed Liquor Suspended Solids (MLSS) and Mixed Liquor Volatile Suspended Solids (MLVSS) with time during the operation of the lab-scale MBBR is presented in Figure 3.3

During the initial phase of reactor operation, relatively lower MLSS and MLVSS concentrations were observed, which can be attributed to the acclimatization period of microorganisms to slaughterhouse wastewater. As the reactor operation progressed, both MLSS and MLVSS showed a gradual increase, indicating active microbial growth and stabilization of the biological system.

The increasing MLVSS/MLSS ratio reflects a healthy and efficient microbial population capable of degrading organic pollutants effectively (9).

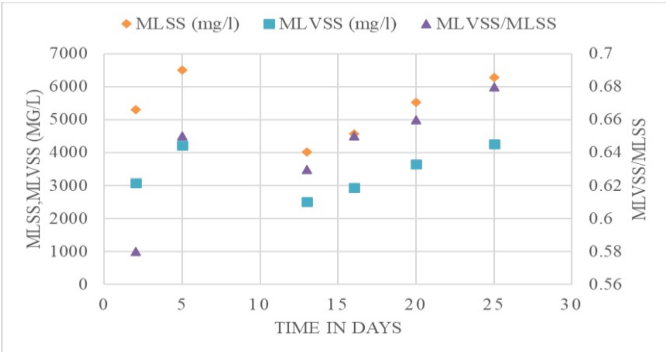

Fig. 3.3: MLSS and MLVSS vs TIME

3.4 Variation of influent and Effluent PH

The variation of pH during the operation of the lab-scale Moving Bed Biofilm Reactor (MBBR) treating slaughterhouse wastewater was monitored regularly to assess process stability. The pH of the influent and reactor mixed liquor remained within a range of 6.8–7.8 throughout the experimental period.

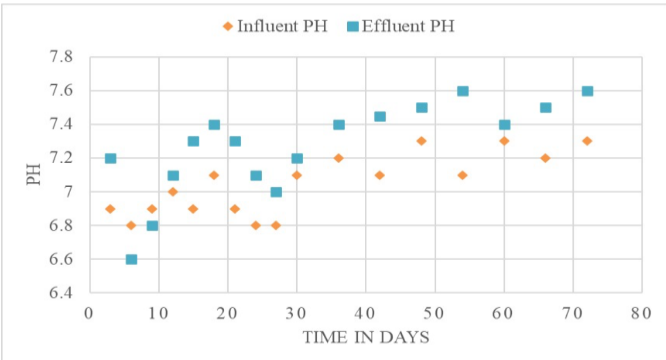

Fig. 3.4: Influent vs Effluent vs Time

3.5 Dissolved Oxygen Monitoring

During the experimental period, the concentration of DO in the reactor was maintained between 3.0-4.5 mg/L. During the initial operational period, there were minor variations in the DO concentration due to the acclimatization of biomass and the increased demand for oxygen. Once the reactor attained a steady state, the DO concentration stabilized, signifying a proper balance between oxygen supply and consumption by microorganisms.

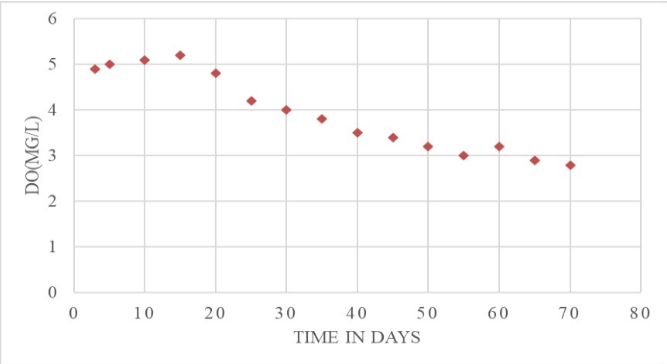

Fig. 3.5: Do Monitoring vs Time

3.6 Development of Biofilm on carriers in MBBR

Biofilm carriers were used in the Moving Bed Biofilm Reactor (MBBR) to provide a large surface area for microbial attachment and growth. The carriers remained in continuous motion due to aeration, ensuring uniform contact between wastewater, microorganisms, and oxygen.

The attached biofilm on the carrier surface played a dominant role in treatment performance by retaining active biomass within the reactor. This prevented biomass washout and increased the effective sludge age without the need for sludge recirculation (10).

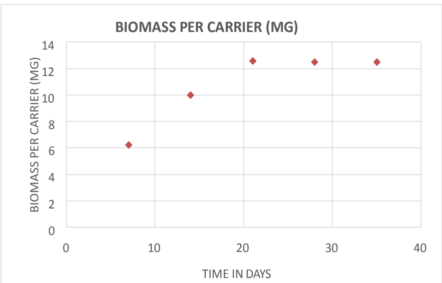

Fig. 3.6: Graph showing variation of biomass per carrier (mg) vs Time

3.7 Ammonia Removal

Ammonia values of the raw wastewater lie between 120-150 mg/l. The percentage removal of ammonia is very high (more than 98%).

3.8 Comparison of MBBR with CAS

Overall performance in the laboratory-based investigation demonstrates that MBBR has a higher constituent removal efficiency rate than CAS (Conventional activated sludge) (11).

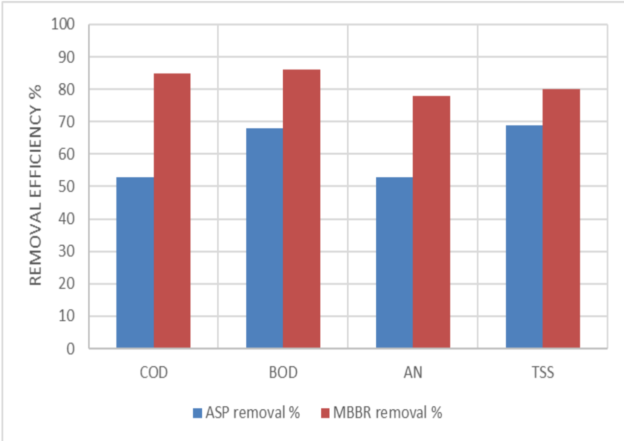

Fig. 3.8: Comparison between MBBR and CAS

4. CONCLUSION

The MBBR was operated over a period of 75 days, and effluent was treated in batch mode. The following conclusions were drawn from the study: MBBR was found effective in removing the COD and BOD of the wastewater by 85.25 % and 86.75% at an organic loading rate of 1.49 $kg/m^3/d$ COD. As the organic loading rate was increased step wise the reactor was still able to achieve 82.5% reduction in COD even at higher organic loading rate of 1.984 $kg/m^3/d$ COD. The MBBR was also found effective in the removal of NH3-N to an extent of 98%. The suspended biomass concentration of the MBBR was nearly 4500mg/l while attached biomass concentration was about 1200mg/l. This was on account of a thin film being formed on the carrier surface. The overall COD and BOD removal efficiency of the MBBR method was 85.25% and 86.75%.

5. REFERENCES

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