

APPLYING BIOFILM HYBRID SYSTEM (ANAEROBIC-AEROBIC) USING CORAL AS MEDIA ON AUTOMOBILE WASTEWATER TREATMENT

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ABSTRACT

In this research, automobile wastewater treatment was performed using the Hybrid system (Anaerobic-Aerobic) with coral media. The coral media is not only cheap, available but also gives high efficiency of COD and Total Kjeldahl Nitrogen removal due to its pore structure. The inlet and outlet samples were collected and analyzed daily. The research was conducted in two phases: adaptive and operative phase. During the adaptive phase, the model was operated for 2 weeks to form biofilm on the coral media. The operative phase in which divided into three periods corresponding to the organic loading rates of 0.25; 1 and 2.5 kg COD/m³d. In these stages, the efficiencies of COD and TKN removal was high and stable. Particularly, COD removal efficiencies was $74.1 \pm 6.7\%$; $80.37 \pm 12.2\%$; $88.1 \pm 6.4\%$, while those of TKN were $66.59 \pm 9.7\%$; $70.81 \pm 7.7\%$; $79.39 \pm 6.2\%$, corresponding to the three different organic loading rates, respectively.

Keywords: Automobile wastewater treatment; coral media; biofilm; hybrid system; MBBR.

1. INTRODUCTION

Most of stages in car production consume water, and releases a large amount of wastewater into the environment. The main pollutants in the automotive wastewater are including grease, wastewater from the painting process, leading to a high concentration of organic matters and nutrients in the influent. Many biological techniques such as ammonification, nitrification/ denitrification and Anammox were investigated to treat this kind of wastewater.[1]

Hybrid a bioreactor is a bioremediation model that has a combined presence of different types of bacteria including suspended – growth bacteria and biofilm bacteria that grow under anaerobic, aerobic as well as anoxic conditions. [2-4]. The hybrid bioreactor system can eliminate recirculation of biomass by omitting the secondary clarifier and thereby economizing the entire process. Furthermore, the process reduces the volume of the tank thereby making optimization in reactor design and also imparts stability to the treatment system. In the past, there was a problem in an increase of biomass in a

conventional activated sludge reactor due to difficulty in separation of the large quantity of biomass in the secondary clarifier. These problems are eliminated in the hybrid bioreactor because of the attachment of a portion of biomass to the support medium. It has been established that two to five-fold increase in biomass concentration is possible in hybrid bioreactor compared to that in a conventional activated sludge process [5]. Coral is cheap and available which can be used as a media for biofilm attached to. The multipored structure helps to increase the density of microorganism.

This study aimed to evaluate the performance of the lab-scale biofilm hybrid system through the efficiency of nitrogen, COD removal.

2. MATERIALS AND METHOD

2.1 Wastewater properties

Influent of wastewater was taken directly from the collection tank of car manufacturing wastewater treatment system. The characteristics of the sample water are as the following table:

Table 1. The composition and characteristics of automobile wastewater

No.	Parameter	Unit	Value	Vietnamese Standard 40:2011/Department of Environment resource	
				Column A	Column B
1	COD	mg/L	882 – 2935	75	150
2	pH		10 – 13	6 – 9	5.5 – 9
3	TKN	mg/L	25 – 40	20	40
4	TP	mg/L	145.3 – 320.4	4	6
5	BOD ₅	mg/L	428 – 624	30	50

2.2 Reactor setup

The lab-scale model was designed as shown in Fig.1. The model includes an influent tank; an anaerobic tank which is connected with the aerobic tank. Finally, the output wastewater is stored in the effluent tank.

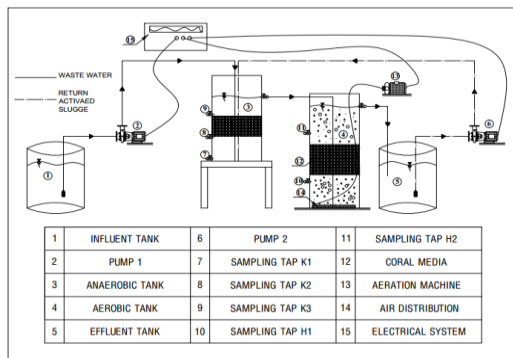


Fig. 1. Reactor setup

Table Error! No text of specified style in document.. Design parameter

No.	Tank	Value
1	Influent tank	D = 75 cm Height: 90 cm
2	Anaerobic tank	W×L×H = 280×140×450 mm H _{coralmedia} = 10 cm
3	Aerobic tank	W×L×H = 280×140×600 mm H _{coralmedia} = 15 cm
4	Effluent tank	D = 75 cm Height: 80 cm

2.3 Experimental design

Activated sludge is filled in tanks with MLSS from 2500 to 3000 mg/L. The system is started by loading the influent to anaerobic. Wastewater is diluted and added into the system with a COD concentration of 200 mg/L. The concentration of DO in the aerobic tank is maintained from 2 to 4 mg/L.

The MLSS and COD input are monitored daily to ensure that microorganism can grow and develop.

After operating in an adaptive phase, on the surface of media have a biofilm. The operative phase was started. This phase includes 3 periods as shown in Figure 2.

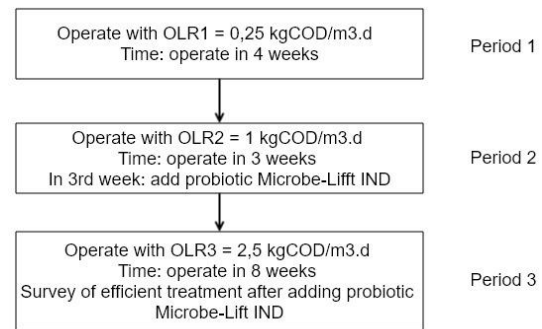


Fig. 2. Schematic diagram of operative phase

3. RESULTS AND DISCUSSION

3.1 Characteristics of coral media



Fig. 3. Coral media before and after use for treatment (A: Initial coral, B: Coral in the tanks)

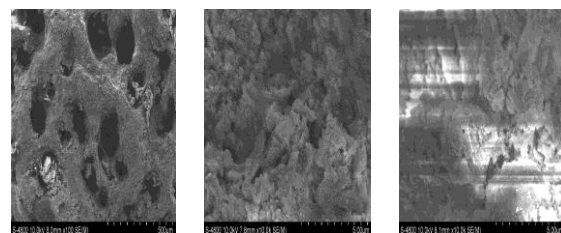


Fig. 4. Scanning Electron Micrographs of attached microorganism on coral media.

SEM photos review the density of bacteria onto coral media. In the beginning, the pores inside coral are very clear, after operated time, the microorganism covered all the pores which help to remove organic matter and nitrogen in the wastewater.

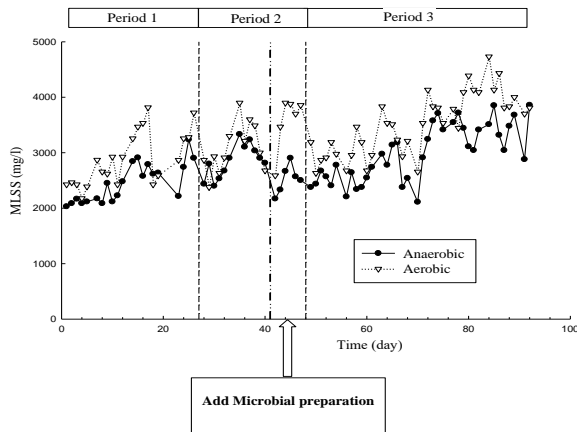


Fig. 5. The change of MLSS in second tanks

MLSS is one of the key parameters in the wastewater treatment process. In the system of wastewater treatment by biological processes, maintaining a high MLSS density has a great effect on improving removal efficiency and reducing hydraulic retention time, as well as being able to treat wastewater with high organic matter content.

The hybrid (Anaerobic – Aerobic) model used coral as filter material. The MLSS in the effluent was retained on the material, which is the basis condition for rapid biofilm formation. Microbial mobility in the membrane increased the removal efficiency.

Figure 5 shows that the MLSS concentration in the effluent through the filter media was retained at the bottom of the anaerobic model and on the material surface at about 80%.

MLSS in the anaerobic tank ranged from 2031 to 3859 mg/L. MLSS in aerobic tanks ranged from 2176 to 4733 mg/L.

3.2 Removal efficiency of COD

COD is a typical pollution parameter in wastewater and commonly used to assess the wastewater quality. For automotive wastewater with a high COD concentration, a

hybrid system combining anaerobic process and aerobic treatment is preferred and the model of the hybrid system was established in this study.

The biodegradation of the hybrid model was highly effective in three stages (74% – 88%). Table 3 presented the effectiveness of COD removal in three periods:

Table 3. Effectiveness of COD treatment in three stages

	Period 1	Period 2	Period 3
Influent	284 ± 39.6	1042 ± 137.1	1941 ± 560.1
Effluent	62.86 ± 11.5	197.56 ± 114.4	225 ± 122.3
Efficiency (%)	74.1 ± 6.7	80.37 ± 12.2	88.1 ± 6.4

Table 3 reviewed COD efficiency in three stages, the model runs with good COD efficiency greater than 70%. In the second and third stages, the performance was increased to a maximum 88%.

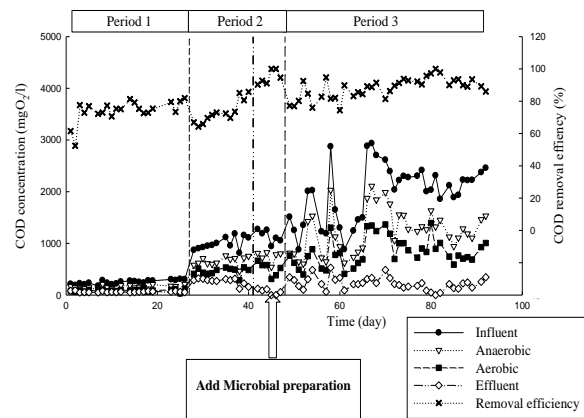


Fig. 6. Profile of COD and removal efficiencies.

Figure 6 showed influent and effluent concentrations and removal efficiencies of COD at different OLR from 0.25 to 2.5 kg COD/m³ per day (concentrations from 200 to 3500 mg/L).

3.3 Removal efficiency of TKN

It was essential to treat the wastewater with a high concentration of TKN since high TKN causes the eutrophication, which could

be toxic to fish and aquatic life. In water, it was also an oxygen-consuming substance that reduces dissolved oxygen in the water. In automotive wastewater, the nitrogen was unchanged and sometimes below standard and was added to ensure efficient processing. Therefore, the value of nitrogen in this study was investigated to ensure a stable biological process. Table 4 shows the efficiency of treating TKN in three stages.

Table 4. The efficiencies of treating TKN in three stages

	Period 1	Period 2	Period 3
Influent	18.73 ± 5.5	36.2 ± 5.2	63.41 ± 9.5
Effluent	6.49 ± 3.1	10.52 ± 3.1	49.74 ± 29
Efficiency (%)	66.59 ± 9.7	70.81 ± 7.7	79.39 ± 6.2

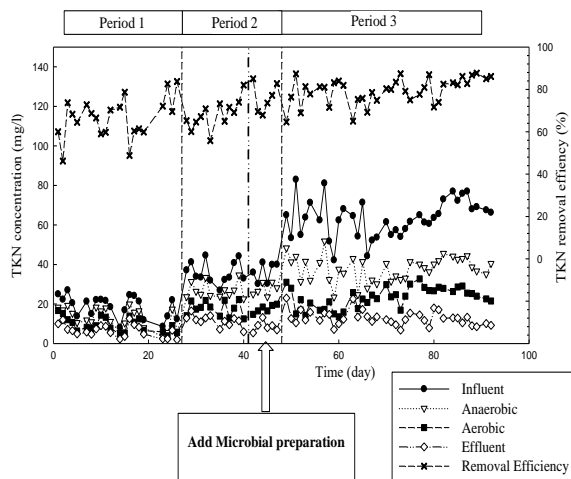


Fig.7. Effluent concentrations and removal efficiencies of TKN

Nitrogen removal experimental results were recorded and are illustrated in figure 7. During the reactor startup phase, the effluent TKN concentration had some fluctuations, the TKN removal efficiency averaged at $66.59 \pm 9.7\%$ and average effluent TKN concentration was 6.49 mg/L. As the increase of influent TKN concentration and the adjustment of the cycle time during period II and period III. To enhance denitrification and increase the organic carbon supply, Microbial preparation Microbe-Lift IND was adopted on day 15 (period II) and during period III. The TKN removal efficiencies increased to $70.81 \pm 7.7\%$ and $79.39 \pm 6.2\%$, and the average effluent TKN concentrations were 9.01 mg/L and 12.87 mg/L. The biofilm contains the anoxic microorganism which helps in degrading the nitrogen in the water.

4. CONCLUSION

The study at the lab-scale was conducted to assess the efficiency of the wastewater the treatment process of the automobile produced by the research model using three OLR as follows: $0.25 \text{ kg COD/m}^3 \cdot \text{day}$, $1 \text{ kg COD/m}^3 \cdot \text{day}$, $2.5 \text{ kg COD/m}^3 \cdot \text{day}$. From the results of the research on the experimental model, the following conclusions could be reached:

High COD and TKN removal efficiency was $74.1 \pm 6.7\%$, $80.37 \pm 12.2\%$, $88.1 \pm 6.4\%$ and treatment efficiency TKN is $66.59 \pm 9.7\%$, $70.81 \pm 7.7\%$, $79.39 \pm 6.2\%$ in 3 stages.

REFERENCES

- [1] H.H. Meghdad Pirsahab, Marius Sebastia Secula, Molouk Parvaneh ,Ghulam Md Ashraf, Application of high rate integrated anaerobic-aerobic/biogranular activated carbon sequencing batch reactor (IAnA-BioGACSBR) for treating strong municipal landfill leachate, *Scientific Reports*, pp.7-15,2017.
- [2] S.J.P. Hyung Sool Lee, Tai Il Yoon Wastewater treatment in a hybrid biological reactor using powdered minerals: effects of organic loading rates on COD removal and nitrification, *Process Biochemistry*, pp.38-45,2002.
- [3] P. Artiga, V. Oyanedel, J.M. Garrido, R. Méndez, An innovative biofilm-suspended biomass hybrid membrane bioreactor for wastewater treatment, *Desalination*, pp.171-179,2005.

- [4] M.-N. Pons, M.d.C. Lourenço da Silva, O. Potier, E. Arnos, P. Battaglia, Modelling of an hybrid wastewater treatment plant, in: B. Braunschweig, X. Joulia (Eds.) *Computer Aided Chemical Engineering, Elsevier*, pp. 907-912,2008.
- [5] D.M. Sushovan Sarkar, Process Design and Application of Aerobic Hybrid, *World Academy of Science, Engineering and Technology International Journal of Chemical and Molecular Engineering*,9, pp.321-335,2015

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