Chemical Oxygen Demand abatement in sewage using Micro-Aeration Enhanced Ecological Floating Bed

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Abstract. The traditional ecological floating bed combined with micro-aeration system and artificial medium was developed for the removal of contaminants and remediation of surface water. This micro-aeration enhanced ecological floating bed (MAEEFB) consisted of aeration unit, microbial processing unit and aquatic plant unit. Batch experiments were conducted in different operating conditions on the removal of chemical oxygen demand (COD) in the sewage using MAEEFB. The removal rate of COD by MAEEFB, enhanced ecological floating bed (EEFB) and traditional ecological floating bed (TEFB) in the same reaction conditions was 59.2%, 56.9% and 30.6%, respectively, indicating that the combination of micro-aeration system and artificial medium could enhance the removal efficiency of COD in TEFB. In MAEEFB, the aeration intensity should be designed reasonablely considering both treatment efficiency and operation cost. Only increasing the specific surface area of the packing cannot effectively improve the purification efficiency of water. Factors like packing material, ability of intercepting organics and complicated extent of microorganisms attaching on the packing should also be considered.

1. Introduction

As water pollution is increasingly prominent, the prevention and control of water pollution and the protection and improvement of water environment are being of great significance for the sustainable development of economy and society. Chemical oxygen demand (COD) is one of the most important indicators for evaluating the organic pollution in water environment.

According to the engineering experience of contaminated water control, wastewater treatment technologies could be roughly classified into three different methods, i.e., physical method, chemical method and biological method [1,2]. Ecological floating bed (EFB) is a promising method for contaminated water repairation. However, the COD removal efficiency using traditional ecological floation bed (TEFB) is relatively low due to the limited surface area of plant root, single microbe species and limited microbe quantity [3-5]. Li et al. [3] used a new type of EFB—micro-aerated ecological floating bed which combined biofilm packing, floating aquatic macrophyte and auxiliary aeration device. This floating bed had a high removal efficiency of ammonia nitrogen and organic, however, this study is lack of the research of packing and aeration intensity.

Recently, the development of a new type of ecological floating bed is receiving increasing attention. Micro-aeration enhanced ecological floating bed (MAEEFB), which is in combination TEFB with micro-aeration system and artificial packing, is a new technique for the purification of contaminated water. This study focused on COD removal using MAEEFB. The influence of different aeration intensity and packing was also discussed. The results from this research may provide theoretical basis and experiential guidance for the application of this technology in the practical engineering.

2. Materials and methods

2.1. Experimental apparatus

This experimental setup included three different types of ecological floating bed, i.e., TEFB consisted of aquatic plants only, enhanced ecological floating bed (EEFB) with aquatic plants and artificial medium, and MAEEFB with aquatic plants, artificial medium and micro-aeration system, as shown in Fig. 1. Rectangular polyethylene plastic water tank (1.0 m × 0.8 m × 0.7 m) was used to simulate lenitic lake in this experiment. A plastic foam board (0.8 m × 0.6 m × 0.03 m) was used as the carrier of the plants. A SB988 aircompressor was utilized as the aeration device, which aerated into MAEEFB through the microporous aeration pipe whose technical parameters are shown in Table 1. Except the research on the effect of different aeration instensity, the aeration was 24 hours uninterrupted in this experiment and its instensity was 2.5 L min^{-1}.

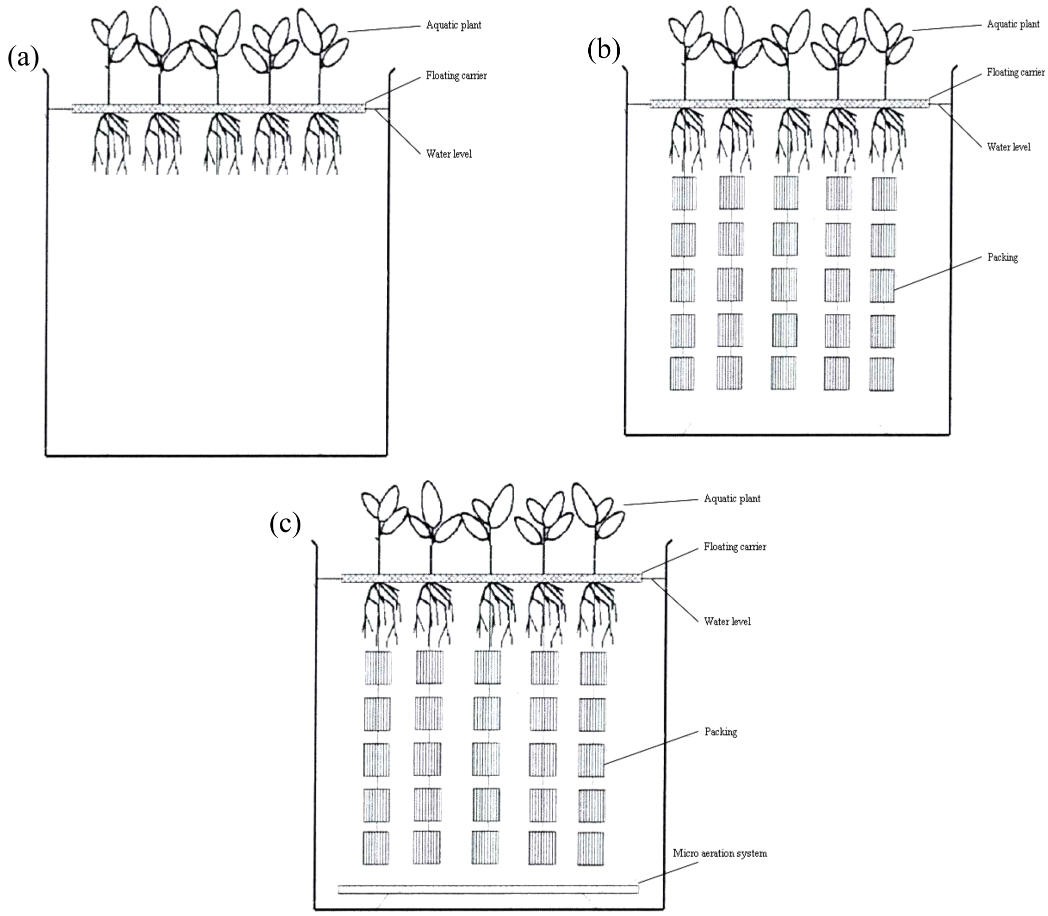

Figure 1. The experimental setup of TEFB (a), EEFB (b) and MAEEFB (c).

Table 1. Technical parameters of micro-aeration pipe

Items	Technical parameters
Aperture	0.03-0.06 mm
Microporous density arrangement	700-1200 m^{-1}

Bubble diameter	0.5-2 mm (fresh water)
Effective aeration intensity	2-6 L min^{-1} m^{-1}
Service area	0.1-0.4 m^3 h^{-1} m^{-1}

2.2. Materials
Based on the selective principle of floating bed plant [6-9], Purple iris, a thelocal common dominant emergent aquatic plant, was chosen in this study due to its favorable features such as cold-resistant, half overcast environment resistant, ability to survive in shallow-water and certain ornamental value . Packing combined with elastic packing was used as the artificial medium, which was suspended into the mixture of activated sludge and experimental water for 7 days to form biofilm before the experiment. Surface water from the lake located in Xipu campus of southwest jiaotong university and sewage from the municipal pipe of the same university (3:1, v/v) were mixed as the experimental water, whose water quality parameters are shown in Table 2.

Table 2. Water quality parameters of experimental water

Water quality parameters	Date
temperature	11 ± 0.5 ºC
pH	7.1
BOD_5	12.6 mg L^{-1}
COD_{Cr}	56.3 mg L^{-1}
TN	9.8 mg L^{-1}
TP	0.43 mg L^{-1}

2.3 Experimental methods
COD was determined using the dichromate method (GB 111914-89). Temperature and pH were measured by a thermometer and pH meter, respectively.

3. Results and discussion

3.1. Degradation efficiency of different EFBs
As shown in Fig. 2, the MAEEFB had the highest removal efficiency of COD and 59.2% COD was removed at the end of this experiment. The removal rate of COD by TEFB and EEFB was 30.6% and 56.9%, respectively. The COD removal efficiency by MAEEFB was almost the same as that by EEFB, while was much higher than that by TEFB. The results indicated that the introduction of micro-aeration system and artificial medium could effectively improve the degradation of the pollutants in EFB. Possible explanation was that the addition of micro-aeration system accelerated the formation of the biofilm in the artifical medium.

At the beginning of the experiment, though the biofilm was not fully matured, the purple iris with well developed root could effectively adsorb the organics, resulting in the rapid decrease of COD in MAEEFB. As the reaction continued, the species and quantity of the microorganisms in the artificial medium increased gradually, which led to continual decline of COD with a considerable speed.

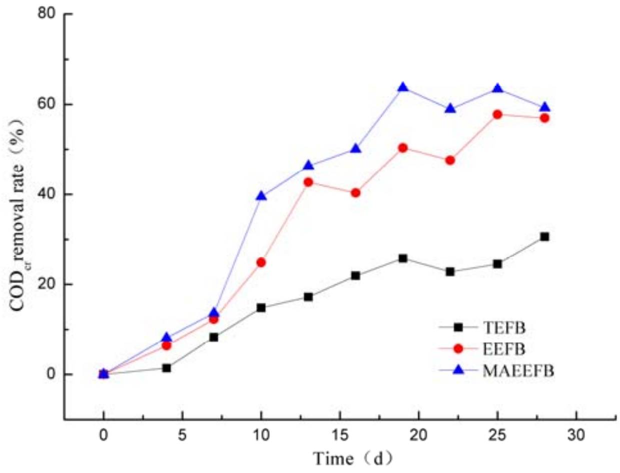

Figure 2. The removal of COD in different EFBs

3.2 Effect of aeration instensity

As shown in Fig. 3, the removal rate of COD in MAEEFB with five different aeration intensities (0.0, 2.5, 5.0, 7.5 and 10 L min^{-1}) was 56.9%, 59.2%, 66.1%, 68.9% and 65.8%, respectively. The removal efficiency of COD was the lowest without aeration, while it was similar in the aeration instensity of 5.0, 7.5 and 10 L min^{-1}. The aeration instensity determined the content of dissolved oxygen (DO) in water.When the aeration instensity reached a certain level, the content of DO would achieve a peak and its variation in the concentration would hardly affect the degradation rate of organic matter based on the analogy of monod equation [10]. Considering the operation cost and treatment efficiency, 5.0 L min^{-1} was the best aeration.

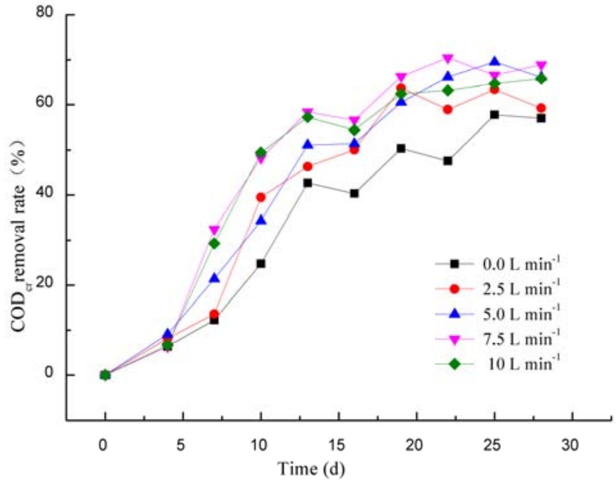

Figure 3. Effect of aeration intensity on the removal of COD

3.3 Effect of different artificial mediums

As shown in Fig. 4, the removal rate of COD in MAEEFB with combined packing, elastic packing and combined packing coupled with elastic packing was 71.7%, 57.3% and 64.2%, respectively. The degradation efficiency of COD was the highest by MAEEFB with combined packing, while it was the lowest by MAEEFB with elastic packing. Because the polyester fiber stucture of the combined packing was beneficial to intercept the organic matter in water and was suitable for the microbial growth, the generation of biofilm in the combined packing was faster than that in the elastic packing.

Only increasing the surface area of packing could not effectively improve the purification efficiency of contaminated water. Factors like packing material, character of organic matter and microbial growth should also be considered.

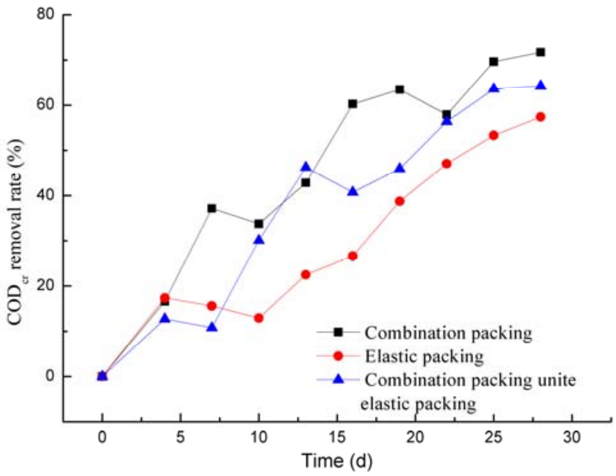

Figure 4. Effect of different artificial mediums on the removal of COD

4. Conclusions

Compared to TEFB and EEFB, MAEEFB had the highest removal efficiency of COD (59.2%) in the same experimental conditions. The introduction of artificial medium and aeration unit could effectively strengthen the removal of COD in MAEEFB. Increasing the aeration instensity could promote the removal of COD, however, the effect of the excessive aeration on the removal of organics was not obvious. Considering the operation cost and treatment efficiency, the aeration instensity should be designed reasonably. The removal rate of COD was the highest by MAEEFB with combined packing, while it was the lowest by MAEEFB with elastic packing.

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