APPLICABILITY OF SUBMERGED AERATED BIOFILTER IN TEXTILE WASTEWATER TREATMENT

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ABSTRACT
In order to evaluate applicability of submerged aerated biofilter (SAF) in removal of organic pollutants from textile wastewater, COD removal performance as well as treatment stability of the process were investigated and compared with those of the activated sludge (AS) process. The results indicated that the SAF proves several benefits against the AS process: The SAF shows significantly higher and stable COD removal efficiency in the whole investigated COD load range of 0.6 – 2.4 kg/m^3/day, more than 80 % against the AS process, 70 – 80 % depending on COD load. The least removal efficiency of dyeing wastewater COD during the treatment for the SAF was estimated to be approximately 70%, remarkably higher than that for the AS process ranging from 40 % to 65 %. COD in treated water and COD removal efficiency of the SAF are less influenced by COD load, indicating that this process is more stable and more easily adapts to the change in influent wastewater characteristics. It is possible to apply a higher COD load for the SAF because of its higher COD removal rate. For example, a COD load of 2.0 kg/m^3/day for this process, twofold higher than that for the AS process can be applied if effluent COD under the level of 100 mg/L is the target of the treatment. Concerning operating conditions, the SAF also shows other advantages such as no requirement of sludge return, easy process control, abilities of reducing excess sludge and eliminating bulking phenomenon.

INTRODUCTION
Water environment pollution caused by textile wastewater discharge has been becoming a pressing issue in several locations in Vietnam because of its extremely high concentration of organic contaminants as well as intense color [1-3]. Due to the recent rapid growth of the textile industry, wastewater discharge from this industry, which was estimated to be more than 30 million m^3/year in 1999 [2] is dramatically increasing year after year. Nevertheless, at present only around 10 % of this effluent is treated, mostly by simple coagulation and sedimentation processes, before discharge [1-3]. Treatment of textile wastewater, therefore, is a deep concern in Vietnam.

Activated sludge (AS) process has been widely applied for removing organic pollutants from textile wastewater. However textile wastewater contains hardly biodegradable substances such as dyestuffs, therefore the process must be operated at low organic load with long hydraulic retention time [4-7] in order to achieve desired treatment efficiency. Consequently, large reactor space is required for the construction of the process. Submerged aerated biofilter (SAF) process, which employs support media for biofilm growth has also been developed for the aerobic treatment of wastewaters during past decades. In this process, because microorganisms attach and are fixed on the surface of contact media high biomass concentration can be achieved, resulting in short hydraulic retention time, high adaptability against the change of influent wastewater characteristics and high stability of treatment efficiency in comparison to suspended growth systems [8]. This process is especially appropriate and effective for the low cell growth rate systems, for example for treatment of low BOD wastewater and nitrification. With those benefits, the SAF process is expected to be appropriate for treatment of textile wastewater that contains hardly biodegradable organic substances causing low biomass conversion. However, data on applicability of this process to textile wastewater are not available.

The aim of this study is to evaluate the feasibility of the SAF in removal of organic pollutants from textile wastewater. COD removal performance of the SAF was examined and compared with that of the AS process. Treatment efficiency, COD removal rate and stability of the two processes will be discussed.

EXPERIMENTAL

Wastewater

Wastewater used in the study was simulated wastewater prepared from effluents generated from sizing and dyeing operations of a textile company (Minh Khai Textile Company). Textile wastewater usually contains both biodegradable and hardly biodegradable organic pollutants. The main biodegradable substance is starch, which is used for sizing and released into wastewater from desizing and kiering operations. On the other hand, the main recalcitrant one is dyestuff generated from dyeing operation. Therefore, starch and dyestuff can be considered as representatives for organic pollutants in textile wastewater. Our estimation based on the consumption data of starch from several textile companies indicated that starch in wastewater accounts for more than 50 % of COD in the whole wastewater effluent. Thus, wastewater for experiments was simulated with the ratio of sizing wastewater COD to dyeing wastewater COD of 1:1. As COD of the two selected effluents is much higher than COD of the actual combined effluent of textile companies, the two wastewaters were mixed together with predefined volumes and then diluted by tap-water to obtain desired total COD values similar to the real combined wastewater generated from textile industry. The experiments were performed in the typical COD range of wastewater from several textile companies in Vietnam between 300 mg/L and 600 mg/L [2, 9]. BOD to COD ratios of sizing wastewater and dyeing wastewater were 0.60 – 0.65 and 0.25 – 0.30, respectively, and that of mixed wastewater used for experiments was in the range of 0.42 – 0.47.

Experiments

Experiments with AS process were carried out using an ASS-20PS activated sludge process device (Myamoto Co., Ltd., Japan) comprising an aeration tank of 20 L, a settling tank of 10 L and automatic controllers of pH, DO and temperature as in Fig. 1. Experiments with SAF were conducted in a COTT-4 submerged aerated biofilter device (Myamoto Co., Ltd., Japan) comprising a biofilter compartment with an effective volume of 15 L and a setting compartment of 7 L as shown in Fig. 2. Contact media as microorganism carriers in the SAF were corrugated bundle plastic media, available in Vietnam, having a specific surface area of approximately 200 m^2/m^3 and a void space of around 95%. Flow-rates of inlet wastewater were controlled by adjusting the speed of metering feed pumps. All experiments were conducted at temperature of 26 ± 0.5 ^oC, pH in the range of 7.0 – 7.5 and DO in the range of 2 – 3 mg/L. MLSS (mixed liquor suspended solid) in the aeration tank of the AS system was maintained in the range of 2000 – 2400 mg/L. Nitrogen and phosphorus sources were added by $(NH_4)_2SO_4$ and KH_2PO_4 solutions with BOD : N : P ratio of 100 : 5 : 1. In the pre-cultivation stage an activated sludge culture taken from an industry wastewater treatment plant was adapted to experiment systems by continuous wastewater feeding. The start-up period was conducted for about one month. Experiments with the SAF was carried out without sludge return.

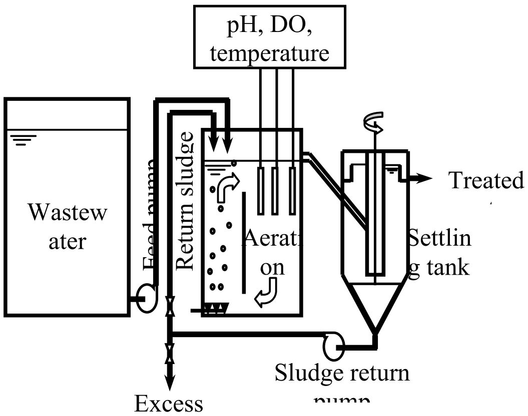

Fig.1 Experimental diagram of activated sludge system

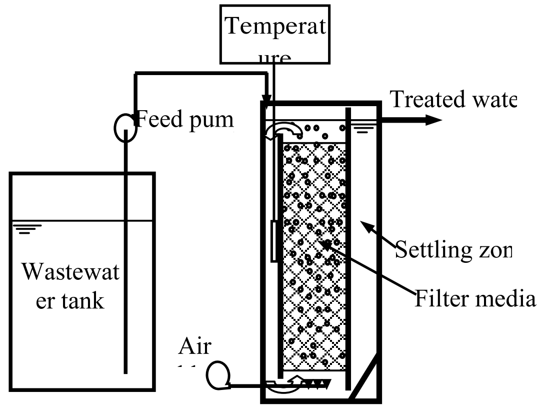

Fig. 2 Experimental diagram of submerged

Analysis

COD was analyzed following the closed reflux - titrimetric method with potassium dichromate as oxidant using a TR320 thermoreactor (Merck, Germany). Experiment data for each different COD load were taken after the steady-state conditions were reached.

RESULTS AND DISCUSSION

COD removal efficiency

Fig.3 shows the effect of COD load on COD removal in the AS and SAF systems. COD load was changed by varying either influent COD in the range of 300 – 600 mg/L or hydraulic retention time in the range of 6 – 20 h, and calculated by the equation (1).

$$L_{COD} = \frac{COD_{in} \times 10^{-3}}{HRT} \qquad (1)$$

where, L_{COD} denotes COD load (in $kg/m^3/day$), COD_{in} is COD concentration (in mg/L) in the influent, and HRT is hydraulic retention time (in day).

It can be seen from Fig.3 that effluent COD and COD removal efficiency in the SAF system are less influenced by COD load than those in the AS system. In the AS system, effluent COD increases and COD removal efficiency decreases when increasing COD load, while significant change in COD removal efficiency is not observed for the case of the SAF system. Moreover, the SAF system achieves higher COD removal efficiency, around 83 % more than the AS system, in the range of 70 - 80 %. The obtained results indicate that, as expectation, the SAF is more stable than the AS process in treatment of textile wastewater. In order to achieve effluent COD less than 100 mg/L to meet the Vietnamese discharge regulation, the operating COD load should be under 1.0 $kg/m^3/day$ for the AS process, whereas it can rise twice for the SAF.

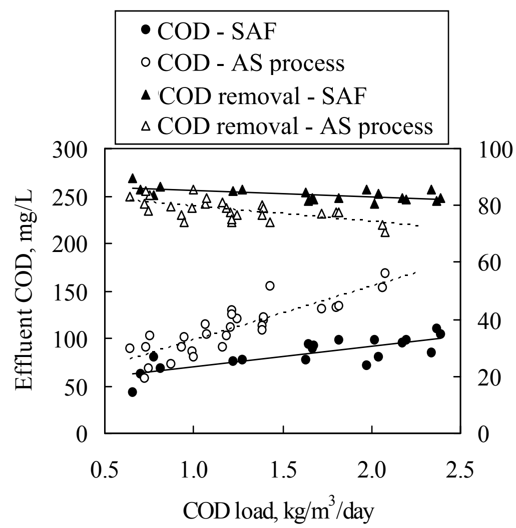

Fig. 3 COD removal efficiency vs. COD load

COD removal rate

Fig. 4 shows the effect of COD load on COD removal rate in the SAF and AS systems. COD removal rate was obtained from the equation (2).

$$r_{COD} = \frac{(COD_{in} - COD_{out}) \times 10^{-3}}{HRT} \qquad (2)$$

where, r_{COD} is COD removal rate, COD_{out} is COD concentration (in mg/L) in the effluent.

It can be seen from Fig. 4 that, in the investigated range, COD removal rates in both systems are proportional to COD load. However, COD removal rate in the SAF system is higher. This indicates that the SAF is more effective in removal of organic pollutants in textile wastewater. From the experiment results, the following empirical relation between COD removal rate and COD load is obtained:

$$r_{COD} = aL_{COD} + b \qquad (3)$$

where, a and b are constants.

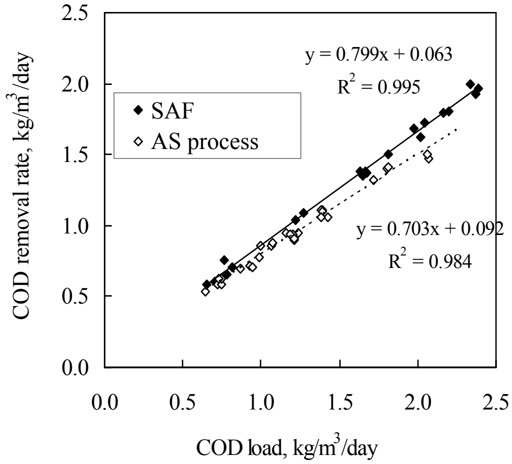

Fig. 4 COD removal rate vs. COD load

From equations (1) – (3), the relation between COD removal efficiency and COD load can be described as follows:

$$\eta = \frac{COD_{in} - COD_{out}}{COD_{in}} \times 100\% = (a + \frac{b}{L_{COD}}) \times 100\% \qquad (4)$$

where, η is COD removal efficiency.

The values of a and b respectively are 0.799 and 0.063 for the case of SAF, and 0.703 and 0.092 for the case of AS process. The lower value of b for the SAF means that COD removal efficiency of this process is less dependent on COD load than that of the AS process.

Dyeing wastewater COD removal possibility

It is worthwhile to estimate the elimination of COD of dyeing wastewater, which is one of the most recalcitrant effluents from textile industry during the treatment in the two processes. By assuming that most sizing wastewater COD was removed, and the effluent COD is mainly the residual COD of dyeing wastewater, one can evaluate the least removal efficiency of dyeing wastewater COD. Fig. 5 shows the evaluation of least removal efficiency of dyeing wastewater COD. It can be clearly seen that the least removal of dyeing wastewater COD in the AS system tends to decrease when increasing the load of dyeing wastewater COD, while that in the SAF system is less sensitive to COD load. The least removal efficiency of dyeing wastewater COD in the SAF system is about 70%, significantly higher than that in the AS

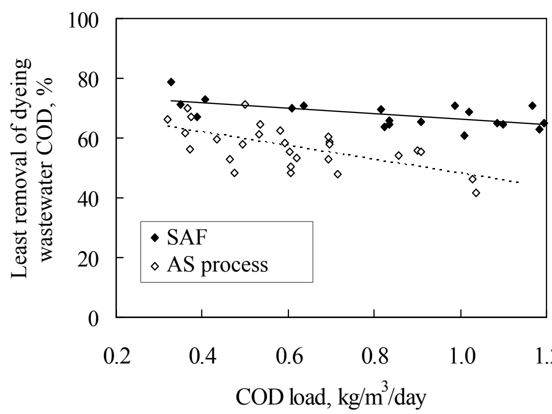

Fig. 5 Dyeing wastewater COD removal efficiency during the treatment

system ranging from 40 % to 65 %. These results again reveal that the SAF is more stable and easier to adapt to wastewater characteristics than the AS process.

In addition, concerning operating conditions it is noted that settleability of activated sludge in the AS system was quite good with sludge volume index (SVI) in the range of 100 – 150 when COD load under 2.1 kg/m^3/day, but bulking phenomenon was likely to occur with purer settleability (SVI of around 200) when increasing COD load. In comparison to AS system, control of the SAF system was quite simple since sludge return was not required for the system.

CONCLUSIONS

1. The SAF shows significantly higher COD removal efficiency, more than 80% against the AS process, 70 – 80% depending on COD load. It was also estimated that the least removal efficiency of dyeing wastewater COD during the treatment for the SAF process is approximately 70%, remarkably higher than that for the AS process ranging from 40 % to 65 %.
2. Effluent COD and COD removal efficiency in the SAF are less influenced by COD load, indicating that this process is more stable and more easily adapts to the change in influent wastewater characteristics.
3. It is able to apply a higher COD load for the SAF because of its higher COD removal rate. For example, a COD load of 2.0 kg/m^3/day for this process, twice higher than that for the AS process, can be applied when effluent COD is under 100 mg/L as required by Vietnamese standard.
4. Concerning operating conditions, the SAF also shows other advantages such as no requirement of sludge return, easy process control, abilities of reducing excess sludge and eliminating bulking phenomenon.

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NGHIÊN CỨU ỨNG DỤNG PHƯƠNG PHÁP LỌC SINH HỌC NGẬP NƯỚC CÓ THỔI KHÍ TRONG XỬ LÝ NƯỚC THẢI DỆT NHUỘM

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TÓM TẮT

Nhằm đánh giá khả năng ứng dụng của phương pháp lọc sinh học ngập nước có thổi khí (còn gọi là oxi hoá tiếp xúc) trong xử lý thành phần hữu cơ trong nước thải dệt nhuộm, khả năng xử lý COD cũng như tính ổn định của quá trình lọc sinh học ngập nước đã được nghiên cứu và so sánh với phương pháp bùn hoạt tính thông thường. Nước thải sử dụng trong nghiên cứu là nước thải tổng hợp được pha chế từ các dòng thải đặc trưng của quá trình dệt nhuộm, tức là nước thải của các quá trình nhuộm và hồ của Công ty Dệt nhuộm Minh Khai. Kết quả nghiên cứu cho thấy, quá trình lọc sinh học ngập nước tỏ ra có nhiều ưu thế hơn quá trình bùn hoạt tính: Phương pháp lọc sinh học ngập nước cho hiệu quả xử lý COD tương đối cao và ổn định, trên 80% trong toàn dải tải lượng nghiên cứu 0,6 – 2,4 kg/m^3/ngày, trong khi đó phương pháp bùn hoạt tính chỉ đạt trong khoảng 70 – 80% tuỳ thuộc vào tải lượng COD. Hiệu suất xử lý tối thiểu đối với COD nước thải nhuộm trong quá trình xử lý của quá trình lọc sinh học ngập nước được xác định là khoảng 70%, cao hơn đáng kể đối với quá trình bùn hoạt tính, chỉ khoảng 40 – 65%. COD sau xử lý và hiệu suất xử lý COD của quá trình lọc sinh học ngập nước ít bị ảnh hưởng bởi tải lượng COD, điều đó chứng tỏ rằng quá trình này có tính ổn định cao hơn và dễ dàng thích ứng với sự thay đổi đặc tính nước thải. Kết quả thực nghiệm cũng chỉ ra rằng, quá trình lọc sinh học ngập nước cho tốc độ xử lý COD cao hơn, do đó có thể áp dụng tải lượng COD cao hơn đối với quá trình này. Ví dụ có thể áp dụng tải lượng COD ở mức 2,0 kg/m^3/ngày cho quá trình này, hai lần cao hơn đối với quá trình bùn hoạt tính nếu mục tiêu xử lý là cần đạt được COD nước thải sau xử lý dưới mức 100 mg/L. Quá trình lọc sinh học ngập nước cũng tỏ ra thuận lợi hơn trong vận hành hệ thống: không cần hồi lưu bùn, điều khiển quá trình dễ dàng, có khả năng giảm lượng bùn thừa và loại trừ hiện tượng bùn khó lắng.