Treating domestic sewage by Integrated Inclined-Plate-Membrane bio-reactor

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Abstract. Membrane fouling shorten the service life of the membrane and increases aeration rate for membrane surface cleaning. Two membrane bio-reactors, one for working and another for comparing, were set up to evaluate the feasibility of alleviating membrane fouling and improving wastewater treatment efficiency by integrating inclined-plate precipitation and membrane separation. The result show that: (1) Inclined-plate in reactor had a good effect on pollutant removal of membrane bioreactor. The main role of inclined-plate is dividing reactor space and accelerating precipitation. (2) Working reactor have better performance in COD, TN and TP removal, which can attribute to that working reactor (integrated inclined-plate-Membrane bioreactor) takes both advantages of membrane separation and biological treatment. When influent COD, TP and TN concentration is 163-248 mg/L, 2.08-2.81 mg/L and 24.38-30.49 mg/L in working reactor, effluent concentration is 27-35 mg/L, 0.53-0.59 mg/L and 11.28-11.56 mg/L, respectively. (3) Membrane fouling was well alleviated in integrated inclined-plate-Membrane bioreactor, and membrane normal service time is significantly longer than that in comparing reactor, which can attribute to accelerating precipitation of inclined-plate. In summary, integrated inclined-plate-Membrane bioreactor is a promising technology to alleviating membrane fouling and improving wastewater treatment efficiency, having good performance and bright future in application.

1. Introduction

Membrane bioreactor (MBR) system combines membrane separation and wastewater biological treatment[1,2]. In this system membrane separation replaces traditional sediment separation system, which makes effluent contain less suspended solids and have higher quality. As one of the most promising wastewater treatment technologies, MBR gets a wide range of applications. But one of the most important defects is membrane fouling which directly affects the economy and stability of the process[3-5].

Membrane fouling shorten the service life of the membrane and increases aeration rate for membrane surface cleaning. In practice, the solution of using perforated pipe aeration cannot meet the requirements of easing membrane fouling. The ratio of gas to water is as high as 20 which outnumbers 6-8 of traditional biological treatment. This is the main reason why the running cost of MBR is higher [5,6].

To solve this question, this research try to combine inclined plate precipitation process with

membrane separating. Inclined plate precipitation decreases precipitation time of partials by the principle of shallow pool precipitation, which equals to effect of increasing precipitation area.

2. Methods and materials

The typical nomenclature is defined in Figure 1. Schematic of the experimental apparatus is shown in Fig 1. The biological treatment system, which is a square biological reactor with a length, width and height of 1000*500*900mm, was set up. Effective depth is 800 mm. Three inclined plates, with that the length and width were 520 and 500 mm respectively and the mounting angle is 60 degrees, were installed at the height of 150 mm from the bottom of the reactor. PVDF hollow cored fiber reverse osmoses membrane was used and installed at 50 mm beneath the inclined plate. The membrane pore diameter was 0.2 um and the aspiration pressure was 0.6 MP. Two reactors was set up to evaluate performance of the process. Reactor 1 is for working and Reactor 2 is for comparison. In reactor 2, the inclined plate was removed, so that the running mode of reactor 2 was the same as a traditional membrane bioreactor.

Wastewater and activated sludge used in experiment were all taken from a municipal sewage treatment plant in China. The concentration of MLSS in both reactor is about 4000 mg/L. The reactor 1 was operated periodically. Operation mode was as follows: aeration 40 min, settling 10 min, suction drainage 10-15 min. 75 L wastewater was filled in and drained out after disposing each cycle. Wastewater was began to fill at the same time of aeration beginning. Suction began 5 min after settling. If the drainage volume was lower than 75 L after 15 min suctioning, working membrane need to be washed. As comparison, reactor 2 was operated continually and its treatment capacity was 75 L/h. the other operation condition was same as reactor 1. Dissolved oxygen (DO) in each reactor was kept at 2~4 mg/L when aerating.

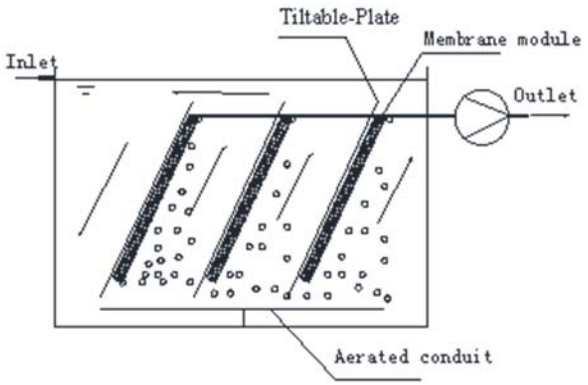


Figure 1. Schematic of the experimental apparatus

Samples were taken at set time each day for quantitative analysis of COD, NO3--N, TP, and TN, which were all tested immediately after sampling. All chemicals used in analysis were of analytical grade. Purkinje General UV spectrophotometer (TU1810) was used for measurements of light absorption. The test items and process were carried out following standard methods.

3. Results and discussions

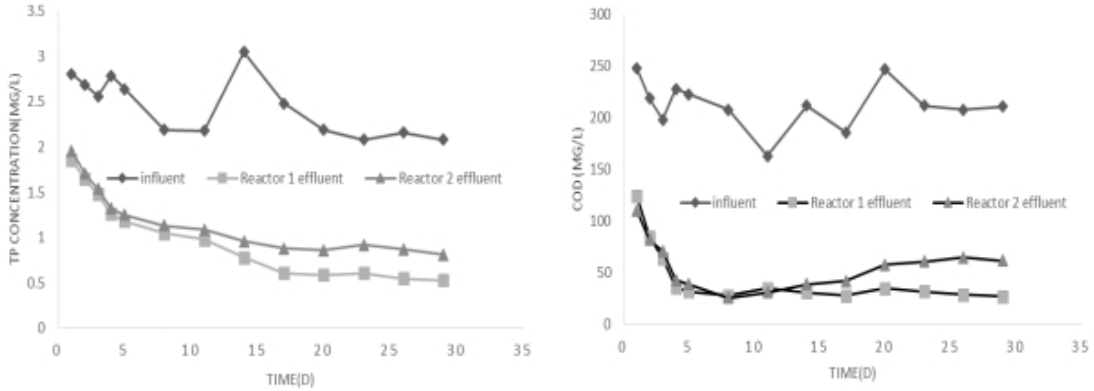
Two reactors continuously ran about 90 days. Removal performance of COD, TN, TP was observed and evaluated. Both of two reactors showed good operating results and COD, TN and TP were disposed well. Effluent quality of reactor 1 was lower than that of reactor 2, which mean that inclined-plate in reactor had a good effect on pollutant removal of membrane bioreactor. The main role of inclined-plate is reactor space dividing and accelerating precipitation. First, reactor space dividing means there are two or more zone in reactor 1 because that inclined-plate itself is impervious to water. So the right space of inclined-plate in reactor 1 is aerobic zone and the left space of inclined-plate is anoxic zone when aerating. At the same time, waste water in reactor 1 is circling through inclined-plate, which is very different from reactor 2. Second, accelerating precipitation of inclined-plate improves water quality of membrane surface which is 50 mm beneath the inclined plate. And membrane fouling rate may decrease, which

could extend the effective period of using membrane and reduce backwashing times.

COD removal of first 30 days is shown in Fig 2-a. As can be seen, effluent COD of two reactors are almost similar at first 12 days. From day 13, reactor 1 have better performance. At day 20, the drainage volume in reactor 2 cannot attain 75 L in 15 min, so the membrane aspiration pressure in reactor 2 was improved to 0.8 MP. As compare, the membrane aspiration pressure in reactor 1 was stable at 0.6 MP and the time consumed in drainage was 12 min. This fact shows that membrane fouling rate in reactor 1 is significantly lower than that in reactor 2, which can attribute to the use of inclined-plate in reactor 1.

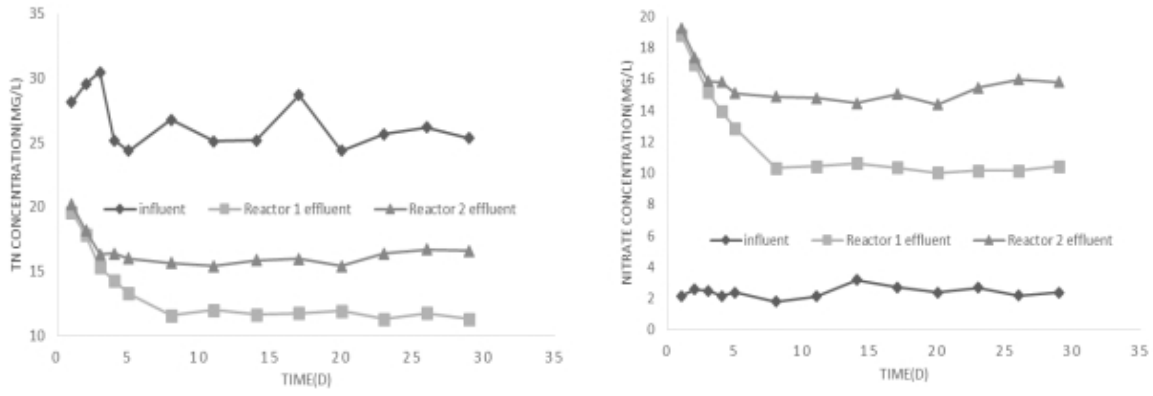
TP removal of first 30 days is shown in Fig 2-b. As can be seen, when influent TP concentration is 2.08-2.81mg/L, effluent TP concentration is stable in 0.53-0.59 mg/L and 0.81-0.92 mg/L in reactor 1 and 2, respectively. Reactor 1 have better performance in TP removal than Reactor 2. In biological wastewater disposal process, Phosphorus accumulating organisms (PAOs) are encouraged to grow and consume phosphorus in systems that need reactor to provide PAOs with a competitive advantage over other bacteria[7-9]. Aerating in reactor 1 make the water flow cycle around the inclined-plate, which divide into two zones: aerobic zone and anaerobic zone. So reactor 1 can provide basic requirements of TP removal. On the contrary, there is only one zone in reactor 2 because of no physical segmentation of inclined-plate. This fact indicates that inclined-plate-Membrane bioreactor take the both advantages of membrane separation and biological treatment in TP removal.

TN removal of first 30 days is shown in Fig 3-a. As can be seen, Reactor 1 have better performance in TN removal than Reactor 2, just as COD and TP removal comparison between two reactors. When influent TN concentration is 24.38-30.49 mg/L, effluent TN concentration is stable at 11.28-11.56 mg/L in reactor 1 and 15.41-16.68 mg/L in reactor 2 from day 8. TN removal by biological process need the cycle of anoxic and aerobic, which is familiar with TP removal in some sense. In reactor 2, missing anoxic process, as a result of no inclined-plate to divide zone, limits TN removal capacity. Variation of nitrate concentration in both reactor prove it. As can be seen in Fig 3-b, when influent nitrate concentration is 1.78-3.16 mg/L, effluent nitrate concentration is stable at 10.14-10.64 mg/L in reactor 1 and 14.38-15.98 mg/L in reactor 2 from day 8, respectively. Because of lacking of denitrification process in reactor 2, nitrate concentration in reactor 2 effluent is higher than that in reactor 1 effluent. Effluent TN and nitrate concentration in both of two reactors have good correlation. So it can be inferred that the difference in TN removal of two reactors mainly attribute to the existing of inclined-plate and membrane separation is the main reason of TN removal in reactor 2.



(a) (b)

Figure 2. The removal of COD (a) and TP (b)



(a) (b)

Figure 3. The removal of TN (a) and Nitrate (b)

4. Conclusion

Two membrane bio-reactors, one for working and another for comparing, were set up to evaluate the feasibility of alleviating membrane fouling and improving wastewater treatment efficiency by integrating inclined-plate precipitation and membrane separation. The result show that:

(1) Inclined-plate in reactor had a good effect on pollutant removal of membrane bioreactor. The main role of inclined-plate is dividing reactor space and accelerating precipitation.

(2) Working reactor have better performance in COD, TN and TP removal, which can attribute to that working reactor (integrated inclined-plate-Membrane bioreactor) takes both advantages of membrane separation and biological treatment. When inclined-plate exists, aerating above the membrane module make the water flow cycle around the inclined-plate and form aerobic zone and anaerobic zone, which is good for TN and TP removal.

(3) Membrane fouling was well alleviated in integrated inclined-plate-Membrane bioreactor, and membrane normal service time is significantly longer than that in comparing reactor, which can attribute to accelerating precipitation of inclined-plate.

In summary, integrated inclined-plate-Membrane bioreactor is a promising technology to alleviating membrane fouling and improving wastewater treatment efficiency, having good performance and bright future in application.

Acknowledgements

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