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Comparison in reduction of solids, turbidity and EC between nanofiltration membrane bioreactor and activated sludge

ABSTRACT

Hospital wastewater has special importance since having pathogens, radioactive materials, pharmaceutical wastes and heavy metals. Removing them into environment without any treatment may cause serious problems for the public health. Membrane Biological Reactor is the combination of the activated sludge and membrane filters. This research has investigated the performance of the Nano-Filtration in a Membrane Biological Reactor (NF-MBR) in the pilot scale in comparison to the activated sludge system which is very common in hospitals and has been utilized in the Babol hospital`s wastewater treatment plant. NF-MBR pilot make the chance for the biological process to act in long SRT (in this case 62 days). Therefore the MLSS concentration in the aeration tank reach to over 6000 mg/l. TDS and EC removal is obtained 60% and turbidity and TSS removal is obtained up to 99%. The advantageous of this system were having no sludge removal in the experimental period, no chemical backwash of the nano-membranes and excellent and nearly constant quality of the effluent.

Keywords: *Hospital wastewater, Nanofiltration Membrane biological reactor (NF-MBR), Turbidity, Total suspended solids (TSS), Electro conductivity (EC).*

F. Golbabaei Kootenaei[1]
M. Ramezani[2]
H. Aminirad[3]
S. Ahmadi[4]
Kh. Pourshamsian[4,*]
M. Fallahnejad[5]

[1]*Department of Environmental Engineering, University of Tehran, Tehran, Iran; Young Researchers Club, Islamic Azad University, Qaemshahr Branch, Iran.*
[2]*Young Researchers Club, Qaemshahr Branch, Islamic Azad University, Qaemshahr, Iran.*
[3]*Department of Civil & Environmental Engineering, Babol Noshirvani University of Technology, Babol, Iran.*
[4]*Department of Chemistry, Faculty of science, Islamic Azad University, Tonekabon Branch, Tonekabon, Iran.*
[5]*Department of Environmental Engineering, University of Tehran, Tehran. Iran.*

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* Corresponding author:
Khalil Pourshamsian
Department of Chemistry, Faculty of science, Islamic Azad University, Tonekabon Branch, Tonekabon, Iran.
Tel +98 9113924792
Fax +98 1924274409
Email kshams49@toniau.ac.ir

INTRODUCTION

Today in many countries such as Iran, various industrial, pharmaceutical and hospital effluents are poured in the rivers and oceans which cause the contamination of the surface and ground water resources. Pollution of the water resources causes different disastrous diseases for the human beings and animals and threats the ecosystem. Considering the health and environment agency alarms about water pollution, using new methods in wastewater treatment for achieving high quality effluent water seems essential [1,2]. Activated sludge system is one of the most popular systems in treating hospital wastewater for many years but the start up and operation of this system required skilled persons otherwise it can have lots of complicated problems.

Although, the microorganisms that do all the job in this system, are suspended in the aeration tank and if the input flow rate suddenly increases, it overflowed from the secondary settling tank and the system loses its performance and therefore, the effluent quality decreases due to the increasing in the turbidity [3,4]. For these reasons, most of the time, the packed systems are not performed accurately and just impose costs for construction and maintenance of the systems.

Using MBR systems eliminates the need for settling tank and disinfection process in the usual activated sludge systems. MBR makes a chance for biological processes to act in 20 to 100 days Sludge retention time (SRT). So input mixed liquid suspended solids (MLSS) concentration increase to over 10000 mg/l. The 93-97% BOD-COD removal and 85-92% nitrification has been proved through different experiments [5-7]. Needing less space due to the removing of settling tank, decreasing in the amount of sludge generation up to 60-75% and also the steady quality of the output effluent are these systems' features [8-10]. In the major countries of the world, it has been proved that this method is the most cost effective ones among the various methods of the treatment [11]. In NF-MBR higher rates for removal of biological contaminants, colloid particles, microorganisms, turbidity and elements such as irons and manganese must be seen.

Considering the fact that wastewater treatment rules and standards are being more stringent every day and reusing effluent become more important every day, using MBR systems in treating various wastewaters is developed in the most countries of the world. Therefore, there is a need to have a treatment method with high efficiency, low space occupation and less surplus sludge in the hospitals which are constructed in the city centers with no space for new treatment plants or enhancing the existing systems. In this case using nanofiltration instead of micro or ultrafiltration will help to improve the performance of MBR systems to produce effluent with properties that is suitable for reusing in different processes.

Noting the increasing use of MBR and nano filtration processes, the advantages of those systems and decreasing rates in cost of nano-membranes, combining these MBR and nano-filtration systems could improve the performance of wastewater treatment and could solve lots of the problems in the wastewater treatment industry, but performing vast investigation in different fields such as membrane, biological and fouling is necessary. This research has investigated the performance of the Nano-Filtration in a Membrane Biological Reactor (NF-MBR) in the pilot scale in comparison to the activated sludge system which has been utilized in the Babol hospital`s wastewater treatment plant.

EXPERIMENTAL

In this research, in order to treat hospital wastewater, a pilot plant with two plexiglas tank with volume of 80 and 40 liters have been used. The average flow of this pilot was 1 lit/min. In this pilot a PLC panel is located for automatic setting. The pilot has two flowmeters to measure the air volume for aeration and treated wastewater flow. There are two pressure gages in this pilot, one for negative pressure of the vacuum pump and another for the pressure of the backwash pump. The flow diagram of this pilot is indicated in the Figure 1.

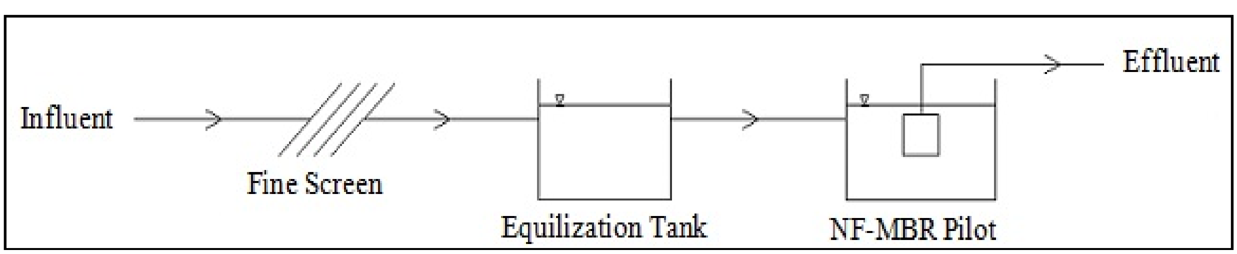

Fig 1. The flow diagram of NF-MBR pilot

This pilot contains aeration, suction and backwash pumps. All the three pumps are the products of HANGZHOU Company in china. The flow of the aeration pump is 420 l/min and the flow of vacuum and backwash pump is about 3 l/min. There were two membrane modules with the area of 4 m^2 in the aeration tank. This membrane has a nominal pore size of 40 nm with inside diameter of 320-350 µm and outside diameter of 400-450 µm.

A plastic tank with a volume of 300 liter is provided to equalize the influent. A pump with flow rate of 3 l/min was used to pump the wastewater from the wastewater collection well to the equalizer tank. The flow of this pump was 3 l/min, considering the fact that the real volume of the tank was 150 liter, retention time was about 2 hours. In the entry of this tank a fine screen with 1 mm pore size is installed to prevent the entry of coarse particles and damaging the nano-membrane modules. Wastewater is poured from the tank to the pilot due to the gravity. All the experiments in all the steps are conducted by the Standard methods for the examination of water & wastewater [12].

RESULTS AND DISCUSSION

Turbidity

The Figure 2 indicates the turbidity values during the experiments. The results indicate that influent turbidity was varied between 162 to 185 NTU. It also demonstrates that the effluent turbidity of activated sludge was about 30 NTU which is not acceptable with standards of Iranian environmental protection agency. In the other side, in NF-MBR pilot, the effluent turbidity is started from 9.4 NTU at the beginning of experiments and ended to 1.6 NTU at the end of the experiments. This turbidity even can meet the standards of potable water in Iran.

Figure 2 also indicates the efficiency of turbidity removal from hospital wastewater for the NF-MBR and Activated Sludge systems. This figure depicts the 80% removal in activated sludge, whereas turbidity removal in NF-MBR pilot starts from 94% and ends up to over 99% at the end of experiments. It can be seen a jump-off in the chart between day 15 and 30 which is the result of forming a cake layer on the surface of the membrane and this layer traps more particles itself and increased the rate of turbidity removal [13].

Total dissolved solids (TDS)

Figure 3 shows the values obtained from tests during the TDS experiments. This parameter indicates the amount of dissolved ions and compounds consisting of metal, non-metal ions and organic matter. TDS values of influent varied from 912 mg/l to 1112 mg/l. Effluent concentration of NF-MBR was 611 mg/l at the beginning of the experiment, and it decreased to 405 mg/l in day 62. On the other hand effluent concentration of the activated sludge system varied between 813 mg/l to 921 mg/l. The Concentration of effluent TDS from membrane systems is directly related to pore size of the membrane, fine pore size causes much more removal of TDS as in reverse osmosis systems almost all the ions will be removed [14].

Figure 3 also shows the TDS removal rate from activated sludge systems and NF-MBR pilot.TDS removal rate reached to over 60 percent in NF- MBR at the end of the research period, but removal of TDS by activated sludge systems is approximately 13% and it shows the superiority of NF-MBR in removal of solids and ions.

Total Suspended Solids (TSS)

TSS represents the amount of suspended solids including inorganic particles and the biological flocs. Figure 4 shows the values obtained from tests of TSS during the trial period. Influent TSS values vary from 136 mg/l to 153 mg/l. Effluent TSS from the pilot plant operation indicates the physical removal of suspended solids in the MBR system and it started from 10 mg/l at the beginning of the experiment to 1 mg/l at the end of it. But the effluent values of activated sludge system are varied from 38 mg/l to 63 mg/l which it cannot meet the standards.

Figure 4 also shows the removal rates of TSS in activated sludge systems and NF-MBR pilot plant. It can be seen in this figure that the removal rate of TSS in the activated sludge system varies between 54 to 73 percent. But removal rate of TSS in NF-MBR pilot is started by 92% at the beginning and reaches over 99% at the end of experimental period. This shows the superiority of NF-MBR system on activated sludge treatment plant. It should be mentioned that in addition to pore size, formation of gel cake layer on the membrane surface has a significant effect on the removal efficiency.

Electro Conductivity (EC)

The concept of conductivity is the rate of electricity conduction through the water or wastewater and has a direct relation with the wastewater ions concentration. In another word, the more ions in the wastewater results the more EC value. The relationship between EC and TDS is as follows [10]:

$$TDS\ (mg/l) = EC\ (\mu S) \times K \qquad K = 0.45 - 0.7 \qquad (1)$$

Figure 5 indicates the result of EC tests during the experiments. The influent EC varies from 1824 µS to 2224 µS. EC rate from the effluent of NF-MBR reactor was started with 1129 µS at the first of the experiments and meet 818 µS at the end of this period. But in the case of activated sludge system in the hospital treatment plant, the value of EC was almost constant and about 1720 µS. EC value in these experiments was almost two times of the TDS rate and the exact value of K was 0.49.

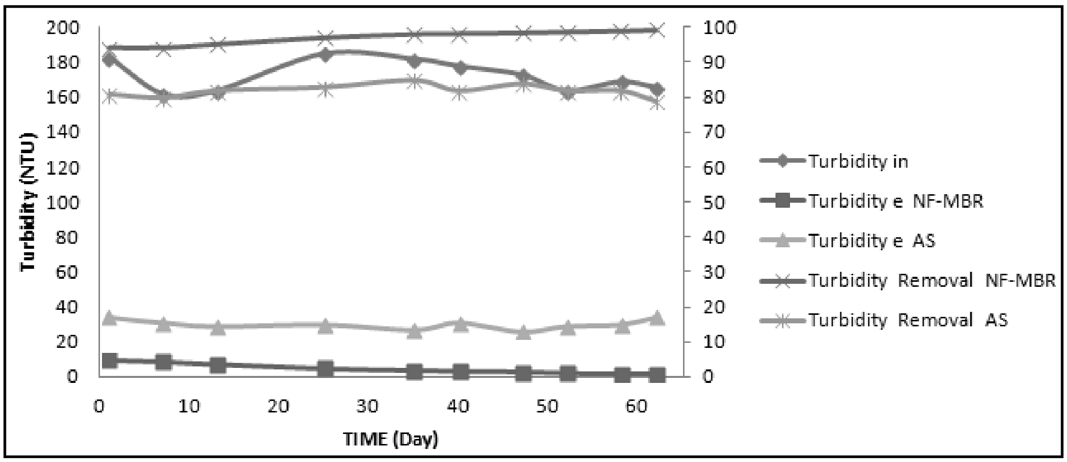

Fig 2. Turbidity values and removal performance

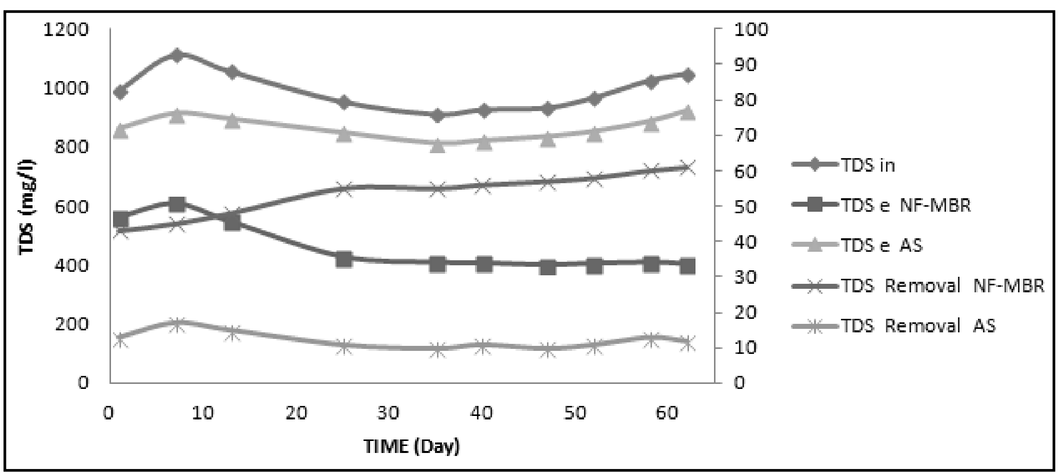

Fig 3. TDS concentration and removal performance

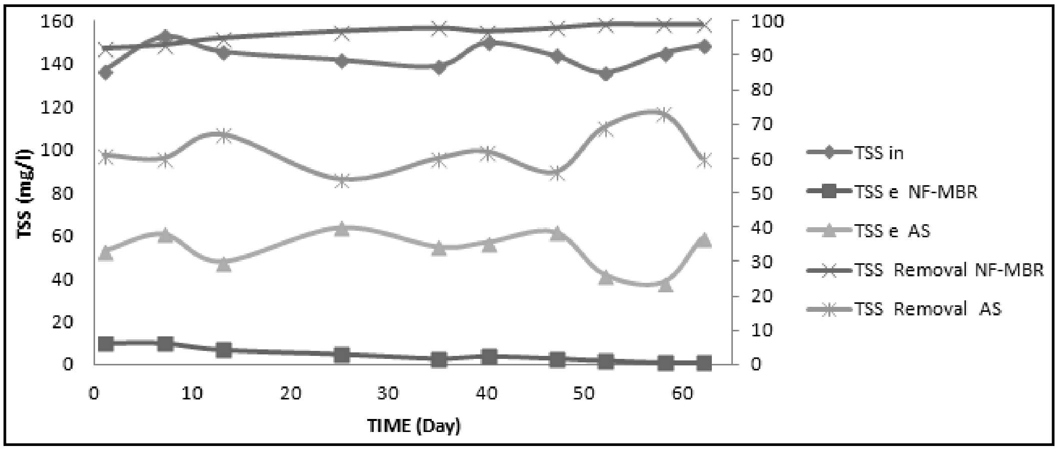

Fig 4. TSS concentration and removal performance

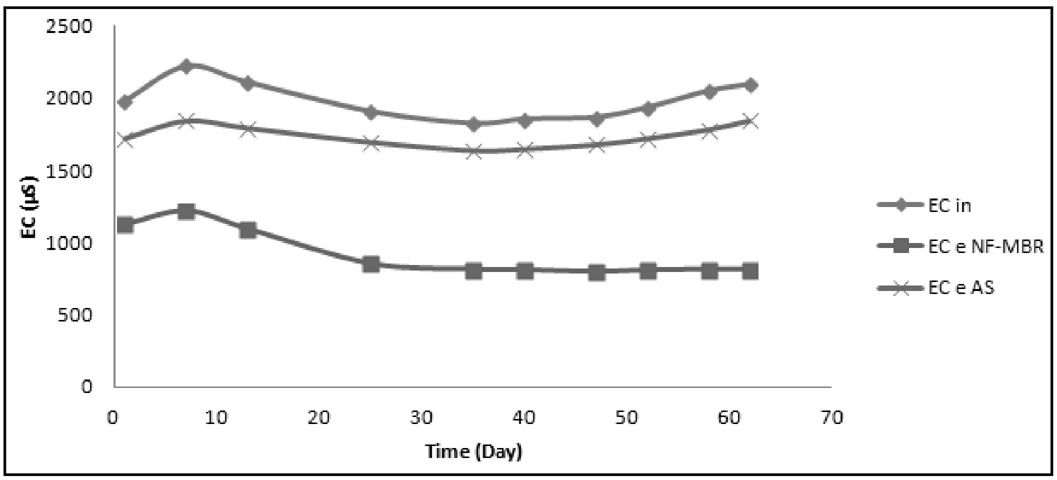

Fig 5. EC concentration and removal performance

CONCLUSIONS

Nowadays, MBR technology has become an important issue. In this system instead of the clarification unit, there is a membrane module for separating solids and MLSS from the treated wastewater. The results showed that the MLSS concentration in MBR Pilot is more than 6000 mg/l. The TDS, TSS, EC and turbidity of the NF-MBR effluent is 405 mg/l, 1 mg/l, 818 µS and a 1.6 NTU, respectively. The same parameters concentration in the hospital treatment plant (AS) is respectively 900 mg/l, 50 mg/l, 1720 µS and 30 NTU which those concentrations are higher than the standards of environmental protection agency of Iran. Removal rate of TDS and EC in MBR system is 60%, TSS removal rate is 99% and turbidity removal is over 99%. But the removal of these parameters in activated sludge system is 13, 13, 60 and 80 percent respectively. These results indicate that treatment plant of this hospital is incapable of treating hospital wastewater. Considering the results of NF-MBR Pilot plant changing the activated sludge system to nanofiltration membrane bioreactor (NF-MBR) system can be proposed for improving the performance of hospital`s treatment plant.

Considering the outcomes of the experiments for treating the hospital wastewater, it can be resulted that NF-MBR is an efficient system for higher removal rates of the contaminants from the hospital wastewater compare to elder systems due to the higher MLSS concentration and applying the novel nano membranes in it. Also the small volume of NF-MBR system is another significant point in applying this system in the hospitals of the Iran since most of these hospitals are constructed in the cities and there is no space for new treatment plants.

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