

*Original Article***Performance Evaluation of Moving Bed Bio film Reactor in Saline Wastewater Treatment**Mahdi Ahmadi,<sup>1,2</sup> Nadali Alavi,<sup>1,2</sup> \* Nematollah Jaafarzadeh,<sup>1,2</sup> Mahdi Barfar,<sup>3</sup> Zeinab Ghaedrahmat,<sup>2</sup> Faezeh Hashemi,<sup>2</sup>

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**Abstract**

**Background and purpose:** Moving Bed Biofilm Reactor is an aerobic attached growth with better biofilm thickness control, lack of plugging and lower head loss. Consequently, this system is greatly used by different wastewater treatment plants. High TDS wastewater produced petrochemical, leather tanning, sea food processing, cannery, pickling and dairy industries. The aim of this study was to evaluate the performance of MBBR in saline wastewater treatment.

**Materials and methods:** In this study, 50 percent of a cylindrical reactor with 9.5 liter occupied media with  $650 \text{ m}^2 \cdot \text{m}^{-3}$ . In the first step, hydraulic regime was evaluated and startup reactor was done by sanitary sludge. Bio film was generated with glucose as the sole carbon source in synthetic wastewater. MBBR performance evaluation was performed in 6:30 and 8:45 with saline wastewater after bio film produced on media.

**Results:** After 83 days of passing MBBR operation with saline wastewater containing 3000-12000 mg.L<sup>-1</sup> TDS, organic loading rate of 2.2-3.5 kg/m<sup>3</sup>.d COD removal efficiency reached 80-92%.

**Conclusion:** Moving bed biofilm reactor is effective in organic load elimination from saline wastewater.

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**Key words:** Moving Bed Bio film Reactor, Saline Wastewater, Organic load

## 1. Introduction

Saline wastewater containing high concentration of mineral salts is mainly the result of petrochemical plants, leather industries, sea food production, desalted units, vegetable conservation, and pickling and dairy production (1, 2).

Many of these industries depend on obsolete technologies for wastewater treatment and cause crucial water pollution. Discharge of these effluents, unfortunately usually comprising high level of organic materials undesirably imposes quality of drinking water, aquatic animals' ecosystem, and agriculture. Thus many countries have striven to establish more district standards for management of saline wastewater in the past decade and in this regard there was much attention paid to effectively treatment of saline wastewater for organic or inorganic materials with various physicochemical methods such as adsorption, solvent extraction and chemical oxidation, However, these methods such as reverse osmosis and ion exchange are limited by high expense (3-7).

On the other hand, considering simple operation and maintenance, cost effectiveness, and treatment without hazardous by products, biological processes are attracting more interests (6). Low adaptability and sensitivity to ionic strength changes cause low efficiency in removal of organic material and suspended solids (8). There are reports indicating unfavorable effects of high salt concentration on the treatment of organic materials and the sludge satiability. Some authors have proposed that continual utilization of sodium chloride in the biological treatment systems does not interfere with removing organic materials and results in very well biomass coagulation. This finding demonstrates that biomass adaptation and salt level are important factors that may explain these observations (1).

In recent years, attached growth processes have been employed for treatment of the industrial wastewater (9). The adverse effect of salt was reduced in attached growth processes because of high sludge retention time (10,11). Moving bed

biofilm reactor (MBBR) is an aerobic attached growth process that has unique advantages such as better control over biofilm thickness, absence of clogging and less pressure drop (5). In fact, many wastewater treatment plants now have employed MBBR for wastewater treatment (12). The MBBR was first developed in Norway during late 1980s and early 1990s (13). This reactor is usually filled with low density polyethylene beds, 10 mm diameter and 8 mm height and 500 m<sup>2</sup> specific areas (14). The main idea behind this system is continuous operation of biofilm reactor with high biomass density and without back washing or sludge recirculation (15).

In contrast to other biofilm reactors, MBBR employs all the tank volume for biomass growth and is very efficient in toxic pollutants removal. This system is very stable against toxic and hydraulic shock load and is suitable for low temperatures (16, 17).

Eugor has reported that synthetic wastewater treatment with 0 to 6 percent salt concentration and 60 mg/l nitrogen and 1200 mg/l COD in the four stage SBR process (anaerobic/aerobic/anoxic/aerobic) with the hydraulic retention time 1/1/3/1 hours respectively and the *Halobacterhalobium* results in COD removal at the rate of 10.7 to 34 mg/gr COD (16).

In another study in 2006, it was found that synthetic wastewater treatment in up flow anaerobic attached growth process, 0 to 5 percent salt concentration, 60 mg/l nitrogen, 1900-3600 mg/l COD, and hydraulic retention time 11 and 30 hours resulted in 84 percent COD reduction, *Halanaerobiclecu* was dominant halo tolerant anaerobic bacteria (18).

The olive plant wastewater was treated by using two-stage biologic system (aerobic and anaerobic digestion). The organic load was 0.3 kgCOD/l.d with 1.25 lb/l.d biogas production which yielded 93 percent COD reduction. 54% of phenol is degraded during aerobic process and the biogas produced during anaerobic digestion contains 68-75 percent methane (19).

Ilela et al. reported that synthetic wastewater containing 0.5 to 3 percent salt concentration and 168 mg/l COD and 48.6 mg/l total kjeldhal nitrogen (TKN) in the activated sludge process and 12 hour hydraulic retention time and inoculation of salt tolerable organisms resulted in 80 to 90 percent removal of COD (7). According to Lee et al. MBBR caused removal of COD and phenol from fish canning wastewater by 81 to 89 percent with 48 hour hydraulic stagnation time (15). The aim of this study was performance evaluation of Moving Bed Bio film Reactor in saline wastewater treatment.

## 2. Methods

In this study a moving bed biofilm reactor and the settling tank with the characteristics presented in tables 1 to 3 and figure 1 was used. Before pilot set up, the hydraulic regime was evaluated. In order to produce biofilm over the bed and to prepare system for biological treatment of wastewater, the reactor was continuously fed by synthetic wastewater containing glucose, methanol and activated sludge from the sanitary wastewater treatment plant. After formation of the biofilm, the efficiency of MBBR in removing organic load from saline wastewater was accomplished at two hydraulic retention time: 6:30 and 8:45.

**Table 1.** Characteristics of MBBR

characteristics	Values
External diameter (mm)	160
Internal diameter (mm)	135
Wall thickness (mm)	25
External height (cm)	65
Internal height (cm)	63.5
Effective height (mm)	440
Total volume (lit)	9.5
Bed volume (lit)	3.2
Effective volume (lit)	6.3

**Table 2.** Characteristics of the settling tank

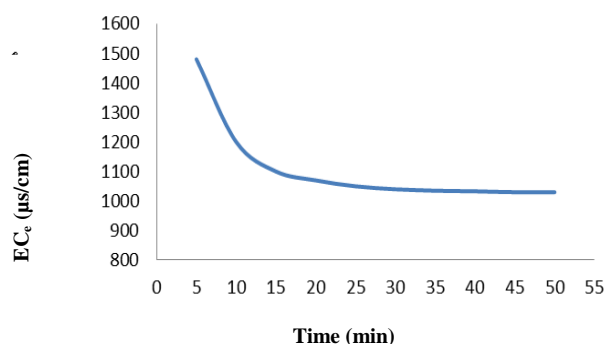
Characteristics	Values
External diameter (mm)	165
Internal diameter (mm)	135
Wall thickness (mm)	25
External height (cm)	35
Internal height (cm)	32.5
Effective height (mm)	21
Total volume (lit)	9
Effective volume (lit)	3

**Table 3.** Characteristics of the packing bed

Characteristics	Values
Color	Black
Specific area (cm <sup>2</sup> )	18
Number of media in each m <sup>2</sup>	36100
Specific area (m <sup>2</sup> . m-3)	650
Density (kg/m <sup>3</sup> )	140
Porosity (%)	87

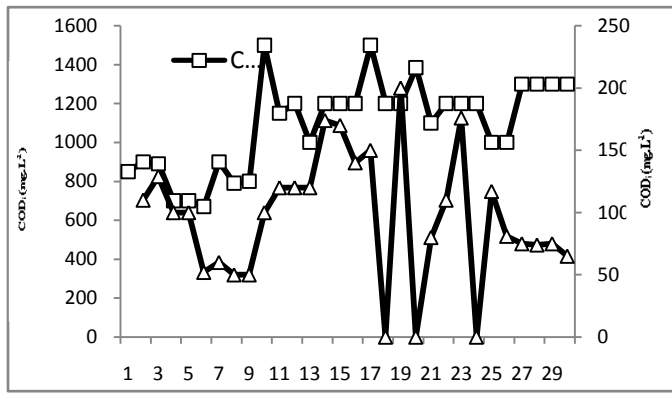
## 3. Results

As the Figure 1 shows, the electrical conductivity in the first 15 minutes was significantly reduced and then stabilized which points to the complete mix regime in the reactor.



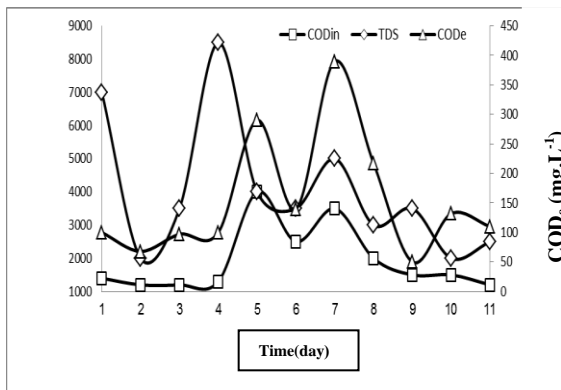
**Figure 1.** Changes in electrical conductivity of the reactor by time

After 30 days, at the hydraulic retention time 8:45 and 1300-800 g/l TDS input, the output COD became stable at 100-150 mg/l. The biofilm was grown on all beds and prepared for final loading.



**Figure 2.** The output COD changes during setting up the MBBR (HRT: 8:45 hours; COD<sub>i</sub>: 700-1500 mg/lit; TDS<sub>i</sub>: 1300-8000 mg/l).

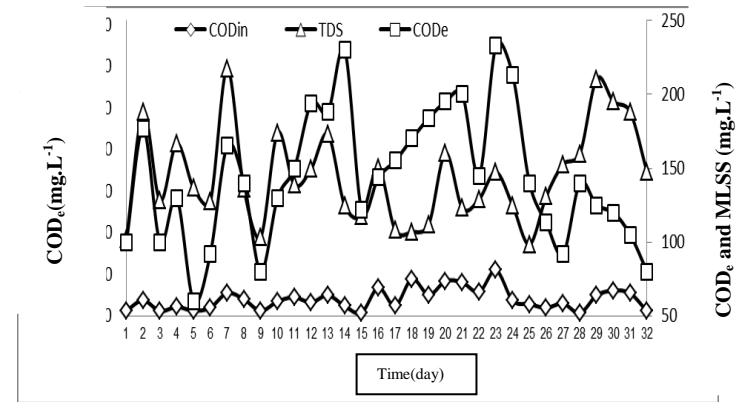
According to figure 3, sudden change in the organic load of the wastewater the rate of COD removal changed. After 24 days, however, it again reached a stable and desirable status. The COD removal efficiency was approximately 95 percent at this stage.



**Figure 3.** The COD changes in the MBBR (HRT: 8:45; COD<sub>i</sub>: 1200-4000 mg/l; TDS<sub>i</sub>: 2000-8500 mg/l).

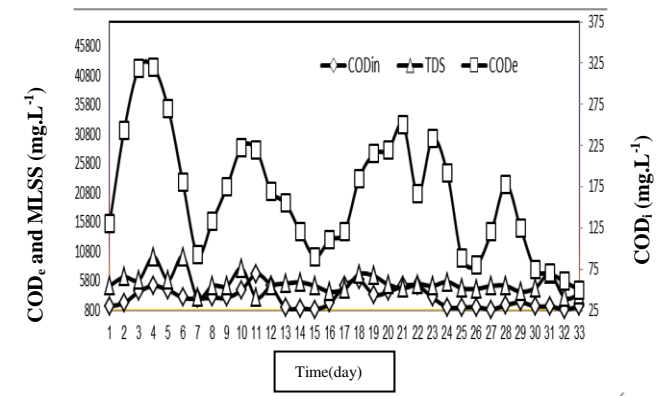
In figure 4, the changes in the effluent COD is shown. In the early days the system encountered a shock. Apparently, there was remarkable fluctuation in the influent and effluent COD. The system became relatively stable almost from day 21 with the COD removal ate of 95 percent though still unstable and became stable from day 27 with the COD removal rate of 88 percent.

Afterwards, there was a reduction in the effluent COD and the removal rate reached 95 percent. The mean effluent COD was almost 150 mg/l with a small change in the COD removal relative to the previous stage.



**Graph 4.** COD changes in the MBBR (HRT: 8:30; COD<sub>i</sub>: 1000-6000 mg/l; TDS<sub>i</sub>: 3000-10000 mg/l).

In Figure 5, the COD changes with 6:30 HRT and 3000-12000 mg/l influent TDS is shown. The reactor was stabilized at approximately day 25. Considering the unpredictable changes in the organic load, the effluent COD was also changed so that COD removal efficiency with 3000-12000 mg/l TDS and 2.2 to 3.5 kg/m<sup>3</sup>/d organic load reached 80-92 percent.



**Figure 5.** COD changes in the MBBR (HRT: 6:30; COD<sub>i</sub>: 400-2200 mg/l; TDS<sub>i</sub>: 3000-12000 mg/l).

## 4. Discussion

Figure 1 shows that the rate of electrical conductivity in the first 15 minutes was decreasing though it reached plateau that is indicative of a complete mixing status in the reactor (20). Izanlu et al have shown that in integrated reactors, especially in MBBR<sub>s</sub>, if the mixing conditions are not optimum, the microbial biofilm and its rotation in the reactor's volume results in high clogging potential. So the reactor design and the placement of air diffusers are very important. It is tried to produce homogenous and small uniform bubbles within reactor increased and the settling and clogging of the reactor is prevented (21).

### 4.1. Setting up the MBBR

Thirty days after setting up the system in a continuous mode with the hydraulic retention time of 8:45 hour and 1300-8000 mg/l influent TDS, the effluent COD was stabilized at 100-150 mg/l. The biofilm was grown on all media and prepared for final loading. The results presented in figure 2 demonstrate that increasing the organic load is effective on biomass formation and the biofilm thickness was increased. Artiga et al reported similar results on conservation wastewater. Their stability status was reached 73 days after setting up the system with 92 percent of COD removal efficiency (22). Li H et al studied phenol, thiocyanate, and ammonium removal from fish canning wastewater using MBBR reactor and after 23 days reached stable COD removal with 81 percent efficiency (15). Labellea et al studied sea water denitrification by submerged MBBR and reported stability after 42 days (23).

### 4.2. Performance evaluation of MBBR in removal of organic load from saline wastewater

In HRT equal to 8:45 and 2000-8500 mg/l influent TDS, COD removal efficiency decreased but after 24 days it reached a stable and desirable status. The efficacy of COD removal was approximately 95 percent at this stage (Figure 3).

In Figure 4, the changes in the effluent COD is shown relative to the time. In the early days the system encountered a shock with apparent fluctuation in the influent and effluent COD. The system became relatively stable almost from day 21 with the COD removal rate of 95 percent though still unstable and became stable from day 27 with the COD removal rate of 88 percent. Afterwards, there was a reduction in the output COD and the removal rate reached 95 percent. The mean effluent COD was almost 150 mg/l with a small change in the COD removal efficiency relative to the previous stage. Artiga et al. reported that treatment of fish canning wastewater with two stage hybrid membrane biological reactor and salt concentration of 84 g/l and 15 g/l for each stage respectively and input COD 7.8-11.8 mg/l and 100 mg/l respectively and the HRT of 73 days and 5 days respectively resulted in 92 percent COD removal. Organic load in the first and second stage was 1.4 kgCOD/m<sup>3</sup>.d and 4 kgCOD/m<sup>3</sup>.d respectively (22). The COD changes with 6:30 HRT and 3000-12000 mg/l influent TDS is shown in Figure 5. The reactor was stabilized at approximately day 25. Considering the unpredictable changes in the organic load, the effluent COD was also changed so that the COD removal efficiency with moderate salt concentration and 2.2 to 3.5 kg/m<sup>3</sup>/d organic load reached 80-92 percent.

Dincer et al reported that synthetic wastewater containing 0-10 percent salt would be biologically treated in a rotating bio disc contactor (RBC). The COD removal efficiency would be reduced if either the COD load or salt concentration was increased. The influent COD was 5000 mg/l and the HRT was 4 hours. The organism used was salt resistant Halobacterhalobium (24). Elela et al have reported that the treatment of synthetic wastewater containing 0.5 to 3 percent salt and 168 mg/l influent COD and 48.6 mg/l TKN using batch activated sludge with HRT 12 hours and halotolerant bacteria resulted in 80-90 percent COD removal (7). The result of the two latter studies was similar to our study and equal to 80-92 percent.



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## References

1. Dan N.P. Biological treatment of high salinity wastewater using yeast and bacterial systems. Ph.D. thesis, Asian Institute of Technology, School of Environment, Resources and Development, Bangkok, Thailand, 2001.
2. Wu, G., Guan, Y., Zhan, X., Effect of salinity on the activity, settling and microbial community of activated sludge in sequencing batch reactors treating synthetic saline wastewater. *J Water Sci. Technol*, 2008; 58(2): 351-358.
3. Juang Ros, Tsai S.Y. Enhanced biodegradation of mixed phenol and sodium salicylate by *Pseudomonas putida* in membrane contactor. *J Water Research* 2006; 40: 3517-26.
4. Fang H.H.P, Liang D.W, Zhang T, Livy. Anaerobic treatment of phenol in wastewater under thermophilic condition. *J Water Research*, 2005; 40: 427-34.
5. Moussavi G, Mohseni M. The treatment of waste air containing phenol vapor in biotrickling filter. *J Chemosphere*, 2008; 72: 1649-54.
6. Moussavi G, Marikbin B, Mahmoudi M. The removal of high concentrations of phenol from saline wastewater using aerobic granular SBR. *J Chemical Engineering*, 2010; 158: 498-504.
7. Abou-elela S.I, M. Kamel M, Fawzy M. Biological treatment of saline wastewater using a salt-tolerant microorganism, *Desalination*, 2010; 250(1): 40299.
8. Lefebure O, Vasudevan N, Torrijos M, Thanasekaran K. Treatment of tannery soak liquor in a sequencing batch reactor. *J Water Research*, 2004; 39: 1471-80.
9. Zhao X, Wang Y, Te Z, Borthwick A.G. L. Oil field wastewater treatment in biological aerated filter by immobilized microorganism. *J Process Biochemistry*, 2006; 41: 1475-83.
10. Kargi F. Empirical models for biological treatment of saline wastewater in rotating bio disc contactor. *J Process Biochemistry*, 2002; 38: 399-403.
11. Afzal M, Iqbal S, Rauf S, M. Khalid M. Characteristics of phenol biodegradation in saline solutions by monocultures of *Pseudomonas aeruginosa* and *Pseudomonas pseudomallei*. *J Hazardous Materials*, 2007; 149: 60-6.
12. Jed Brown J, Glenn E.P, Fitzsimmons K.M, Smith S.E. Halophytes for the treatment of saline aquaculture effluent. *J Aquaculture*, 1999; 175: 255-268.
13. Rusten B, Eikebrokk B, Ulgenes Y, Lygren E. Design and operation of the kaldnes moving bed biofilm reactor, 2005.
14. Salvetti F, Zellino A, Canziani R, Bonomo L. Effects of temperature on tertiary nitrification in moving bed biofilm reactor. *J Water Research*, 2006; 40: 2981-93.
15. Li H.Q, Han H.J, Du M.A, Wang W. Removal of phenols, thiocyanate and ammonium from coal gasification wastewater using moving bed biofilm reactor. *J Bioresource Technology*, 2011; 102: 4667-73.
16. Uggura A. Specific nutrient removal rates in saline wastewater treatment using sequencing batch reactor. *J Process Biochemistry*, 2005; 41: 61-6.
17. Luostarinen S, Luste S, Valentine L, Rintala J. Nitrogen removal from on site treated anaerobic effluents using intermittently moving bed biofilm reactor at low temperatures. *J Water Research*, 2006; 40: 1607-15.
18. Erten, B. and Kapdan, I. "Anaerobic treatment of saline wastewater by halo aero *biomlacusrosei*". *Process Biochemistry*, 2006; 42: 449-453.
19. Martinez - Garcia G, Johnson J, Bachmann R.T, Williams C.J. Two - stage biological treatment of olive mill wastewater with whey as co substrate. *J International Biodeterioration and Biodegradation*, 2007; 59: 273-82.
20. Nabizade, R. Provide a systematic method to analyze the hydraulic regime of activated sludge and attached growth anaerobic reactors. *J Human and Environmental*, 2009; 3(4): 18.

21. IZANHU, H. ePattern of attached growth, aerobic submerged reactor in oil wastewater treatment. PhD Thesis, Tehran University of Medical Sciences, 2008.

22. ARTIGA P, TORIELLO G, MENDEZ R, GARRIDO J. M. Use of a hybrid membrane bioreactor for the treatment of saline wastewater from a fish canning factory. *J Desalination*, 2007; 221: 518–25.

23. LABELLEA M.A, JUTEAUB P, JOLICOEUR M, VILLEMURB R, PARENT S, COMEAU Y. Seawater denitrification in a closed mesocosm by a submerged moving bed biofilm reactor. *J Water Research*, 2005; 39: 3409–3417.

24. DINCER AF, KARGI F. Performance of rotating biological disc system treating saline wastewater. *J Process Biochemistry*, 2000; 36: 901–6.