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Improvement of Diluted Municipal Wastewater Treatment Using the Moving Bed Biofilm Reactor (MBBR)

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ABSTRACT

Nowadays, using combined methods of suspended and attached growth are on the rise due to their effects on the structure volume decrease and efficiency increase in wastewater treatment systems. This paper aims at using the moving bed biofilm reactor to increase the efficiency of diluted municipal wastewater treatment. In most other papers, the used media are called improper due to their high cost, hard application, and availability. As a result, there has been an increasing interest in applying more practical and cheaper method with higher applications in various research areas. In this study Electrical corrugated duct is used as it is cheap, proper, and more available. In order to compare the results prepared of the two similar pilot activated sludge, one is used with media and the other without a media (blank). It should be added that this study was done under environmental conditions and at 13-27 c^o. according to studies, in order to prove the used system efficiency, the biochemical oxygen demand (BOD)was measured at 5 hour, 8 hour, and 15 hour retention time, with the amounts of 75.8%, 71.4%, and 82%, respectively. The achieved results of MBBR system efficiency under the conditions with media at 5, 8, and12 retention times were 7, 5, 3 percent more than those of the conditions without a media. The efficiency of COD removal was 73.4% .63.6%, and 78.2% respectively. The biomass weight at these retention times were 2029, 1133(mg/l), and 448, and SRT (sludge retention time) was 18.74, 16.87, 7.84 day respectively. The carriers occupy up to 40% of the reactor volume on a bulk volume basis.

Mixing the municipal wastewater with surface runoff leads to a diluted wastewater having BOD at 70 mg/lit. According to the fact that the retention time of 5 hours met the need of environmental standards, it was selected as the optimal retention time.

The results showed that MBBR system with Electrical corrugated duct media has a higher efficiency than the ordinary activated sludge system, but this difference is really low in organic load.

KEYWORDS: Diluted Wastewater, activated sludge, biofilm, MBBR, organic load.

1- INTRODUCTION

As most of the existing treatment plants in the country lack the modern world technology and their nominal capacity is completed and on the other hand, as it is not possible to improve treatment plants through increasing the structures, due to the lack of lands, we should look for methods which can increase their nominal capacity and efficiency without increasing the structures. Nowadays, there are a variety of methods to improve the treatment plants which are applied together while their deficiencies is considered as one of biological processes for treatment plants in which the suspended microorganisms are used along with the grown microorganisms on bed. (2.3)

One of the recently applied methods is MBBR system. This system was innovated by a Norwegian company but was patented in the US. In this method, the small polyethylene cylindrical media with density of 0.96 g/cm^3 are added to aeration and non-aeration ponds to have the biological layer. The bed materials might fill the pound up to 25-50 %. Because of the bed materials, there should be efficient little bubble aeration equipment. This process needs no sludge return process (4).

As the reactor is completely mixed, the whole space inside can be used with no flow channelization current problems (5). Studying the effect, form, and size of the carriers in this type of bioreactor shows that as long as the lateral area of the carries is fixed and the size of media has no influence on the severity of treatment (6). The reactors can be operated under aerobic conditions for BOD removal and nitrification or under anoxic conditions for denitrification (7). The carriers can occupy up to 70% of the reactor volume on a bulk volume basis. (8)
(8). In Iran, Kish, MBBR system has been used to improve the treatment plant called Mirmahna (9).

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Due to its being compressed, MBBR system needs less space in comparison to the other systems. It further increases the COD removal amount with more ease. Therefore in order to do the biological treatment and improve the treatment plants for different industries; MBBR is the ideal system (10). MBBR was used in Mashhad treatment plant at the retention times 24 and12 hours to mix the municipal and industrial wastewater, with the retention time 24 hours having BOD removal efficiency of about 81% (11).

In another study done by Madavi and Borgheii (1384), Sanati Sharif university, at retention times 8, 12, it was shown that one of the important reasons to use MBBR is the inlet organic load and the organic materials concentration. If the concentration is low or if the biofilm aeration time is high, a little biofilm is formed. The used media in this study were of KALDNES type (12). The performed studies done on dairy industries wastewater show that inlet phosphorous can reduce from29 mg/l to less than 1 mg/l due to MBBR (13). The purpose of this study is to find out if there is a possibility to increase the efficiency of activated sludge treatment system in treatment plant with MBBR.

2- MATERIALS AND METHODS

The used pilot in this study started in Rasht treatment plant in 2012 and lasted for nine months. In order to find the efficiency of MBBR in wastewater municipal treatment plants, two pilots were used of which one was MBBR and the other was without media for the control MBBR pilot. The control reactor was made to compare the MBBR system results with those of the ordinary activated sludge system. Electrical corrugated duct (1.5 cm x 2.5 cm) was used as a media which looked like a corrugated cylinder (fig1). This media was similar to floor-ramp type media which was used as it was abundant and cheap. Table 1 shows the characteristic of the used media. The media were filled up to 40% of the empty reactor volume. Raw wastewater from screening is transferred to a 500 liter tank and then moved to an aeration tank and after that to a settling tank with a feeding pump and specific discharge. A sieve frame would stop the media to get out of the aeration tank. A blower with 120m^3/h power was used to provide the needed air and also two diffusers were used at the bottom of the tank to have a uniform air distribution. Figure 2 shows the used pilot. In order to better use the results, studies were done under the environmental conditions of the treatment plant and no device was used to stabilize the temperature and other parameters. The inlet wastewater was a mixture of sanitary and surface wastewater and that is why the density of inlet wastewater organic load was low. It should be noted that no synthetic material was used to increase the density. The return active sludge of Rasht treatment plant was used for seeding to make better and faster biofilm. According to the ordinary retention time in municipal treatment plant designing and result another study The retention times were selected at 12, 8 and 5 hour. in each retention time the following parameters were calculated in both pilots.

BOD-COD –SRT-SV1 (sludge volume Index)-DO (dissolved oxygen) - MLSS (Mixed liquor suspended solids) - T (Temperature).

SPSS and Excel software were used to draw graphs and analyses them.

For the better formation of biofilm on media system the retention time 12h was started. Due to low inlet organic load and the high amount of dissolved oxygen, and the low temperature of the system, biofilm was formed really late. Therefore, it did not seem efficient at first, but after 20 days the efficiency improved. Experiments were done according to the publications of 285-2004 of Iran management and planning organization, the sampling guideline, experiments of Iran water and wastewater engineering company in 2003 and “the standard method” book published in 2005(14,15).

Fig1: image of the used media

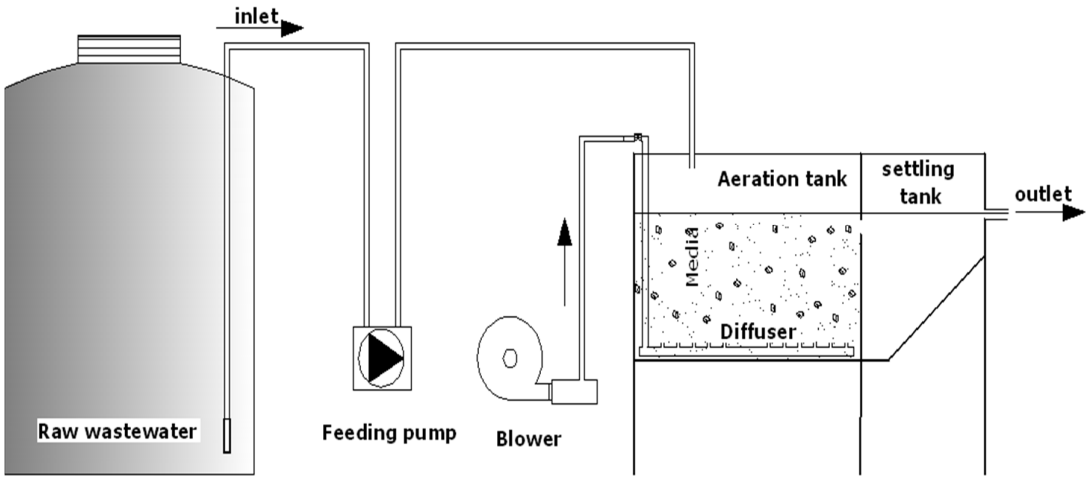

Figure 2: A view of pilot used

Table 1: Characteristics of the media used

Type of Media	Electricity Duct
Material	HDPE
Color	Gray
Height	2 cm
Diameter	1.5 cm
The effective specific surface	100 m^2/m^3
Number of media	5000
Shape	Wave Cylindrical
Density (g/cm^3)	0.95

4- RESULTS

4.1 retention time 12

Average inlet of BOD waste water was about 69 and average outlet was about 26 mg/L which showed the efficiency of about 67.1% for BOD and 54.3% for COD. BOD removal efficiency was 3.1% more than that of control sample. 1-4 graphs show the MBBR inlet and outlet COD and BOD and also present their comparison with control sample and their removal percent.

At this retention time we saw that: SVI =20.25 F/M=0.39, MLSS =448(mg/l) SRT=7.84(day) DO=5mg/L and T=13c^0

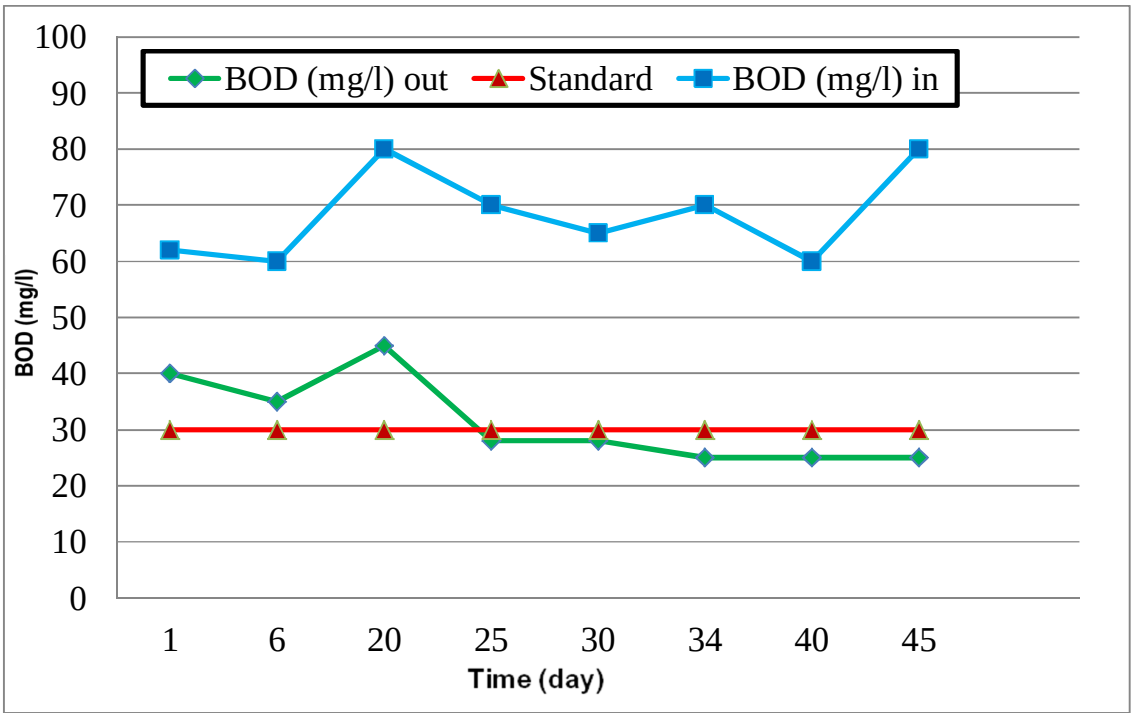

Diagram 1: BOD changes of inlet and outlet MBBR and their comparison with the standard sample at the retention time of 12 hours Diagram

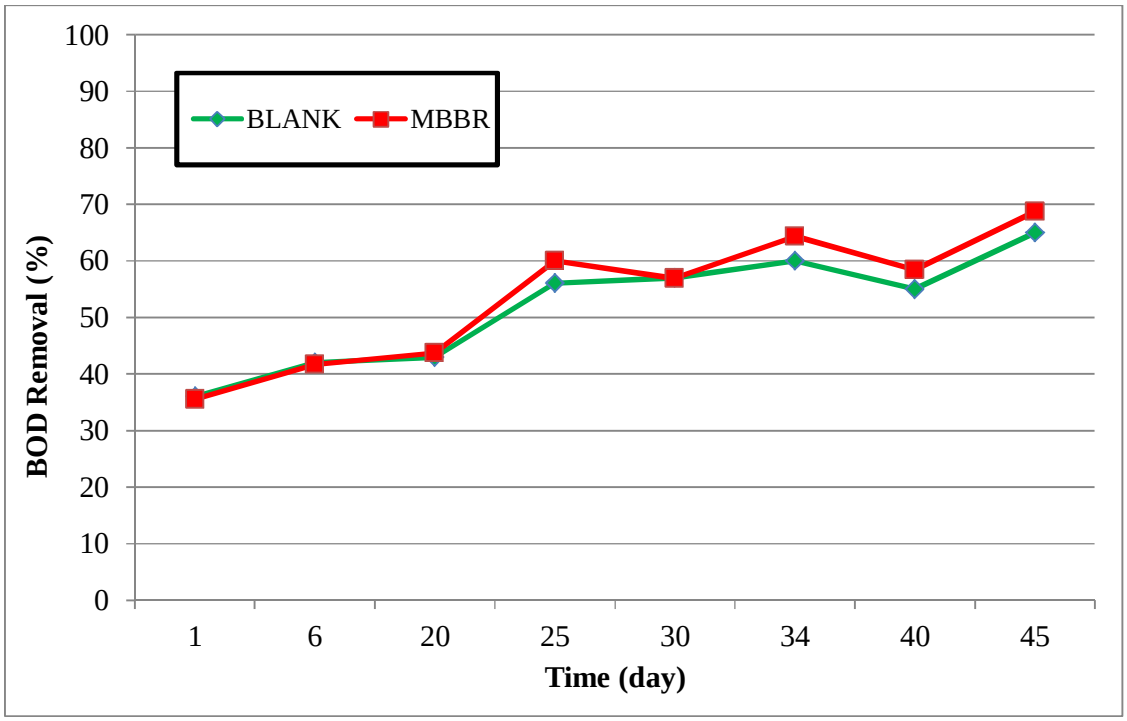

Diagram2: BOD removal efficiency and its comparison with the control sample at the retention time of 12 hours

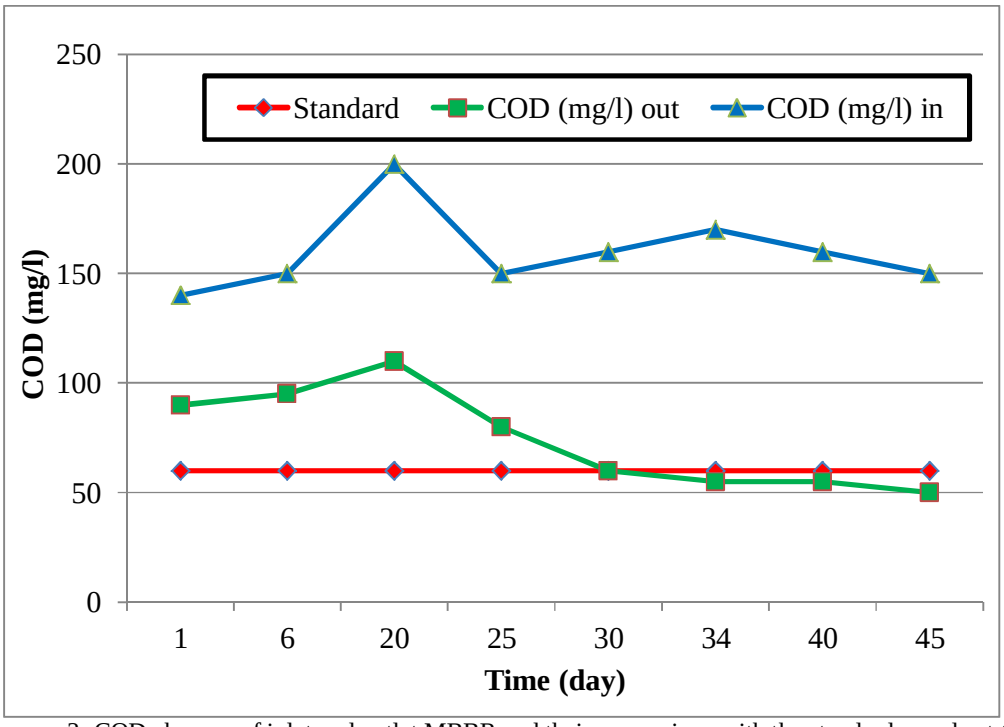

Diagram 3: COD changes of inlet and outlet MBBR and their comparison with the standard sample at the retention time of 12 hours

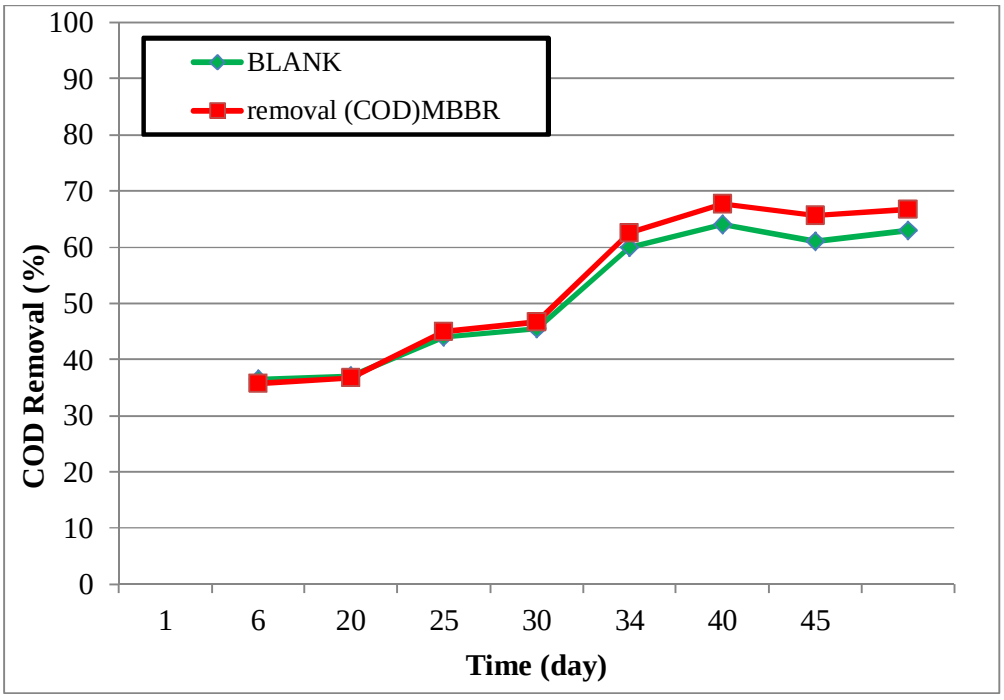

Diagram4: COD removal efficiency and its comparison with the control sample at the retention time of 12 hours.

4- 2- retention time 8 hours

When the outlet was fixed at the retention time of 12 hours, the feeding pump was measured at 15 liter per hour and at the retention time 8 hours along with inlet and outlet parameters .The retention time BOD inlet average was about 75 and the outlet one 21 mg/L and also COD inlet average was 179 while the outlet one equaled 65 mg/L. BOD removal efficiency is about 71.4% and COD removal efficiency is around 63.6%. In this stage, MBBR efficiency is 5.3 % more than that of control one (graphs 5-8).

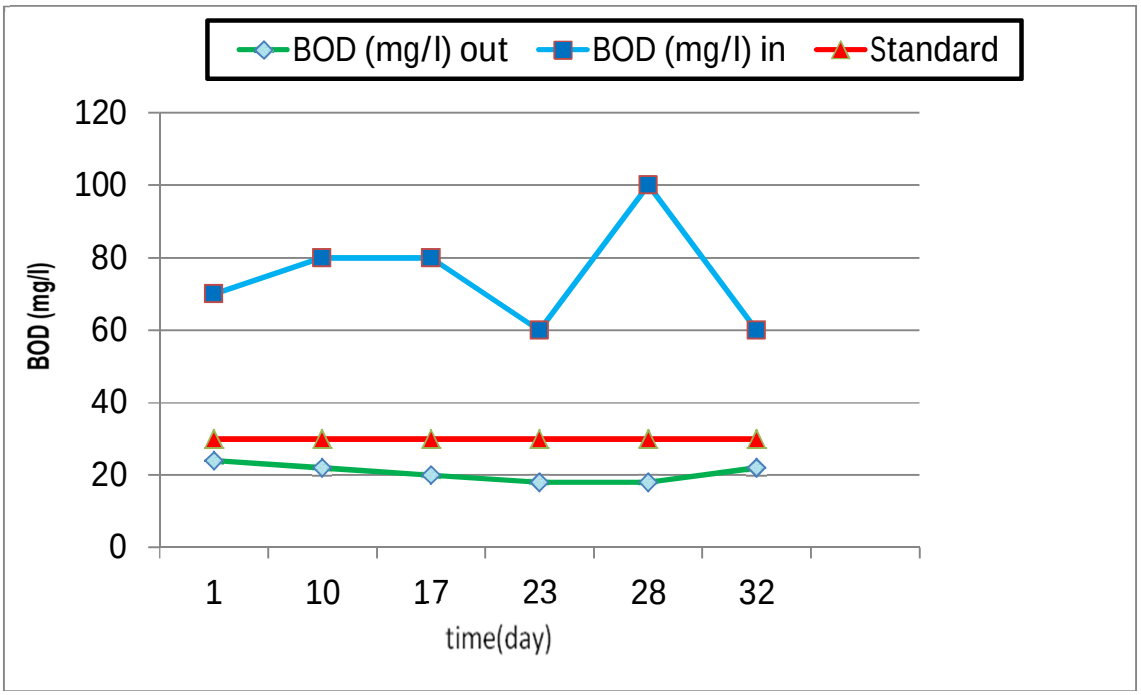

Diagram5: BOD changes of inlet and outlet MBBR and their comparison with the standard sample at the retention time of 8 hours.

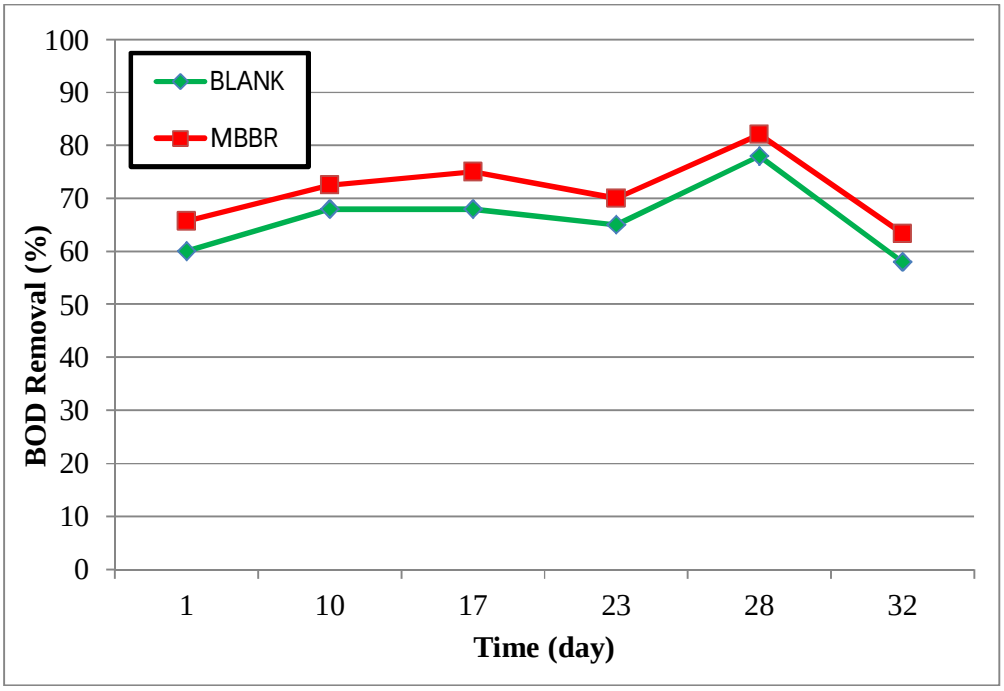

Diagram 6: Diagram of BOD removal efficiency and its comparison with the control sample at the retention time of 8 hours

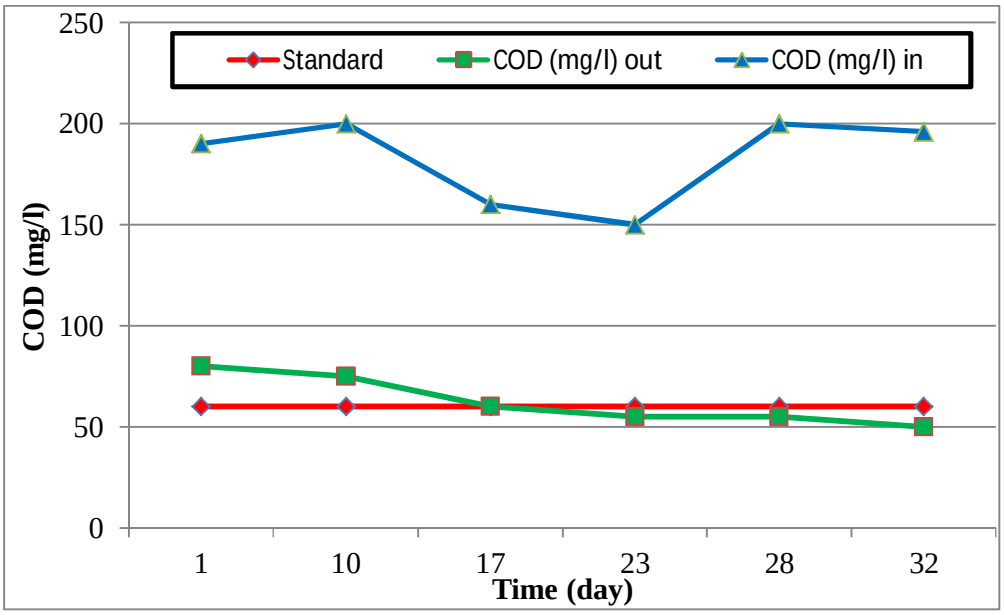

Diagram7: COD changes of inlet and outlet MBBR and their comparison with the standard sample at the retention time of 8 hours.

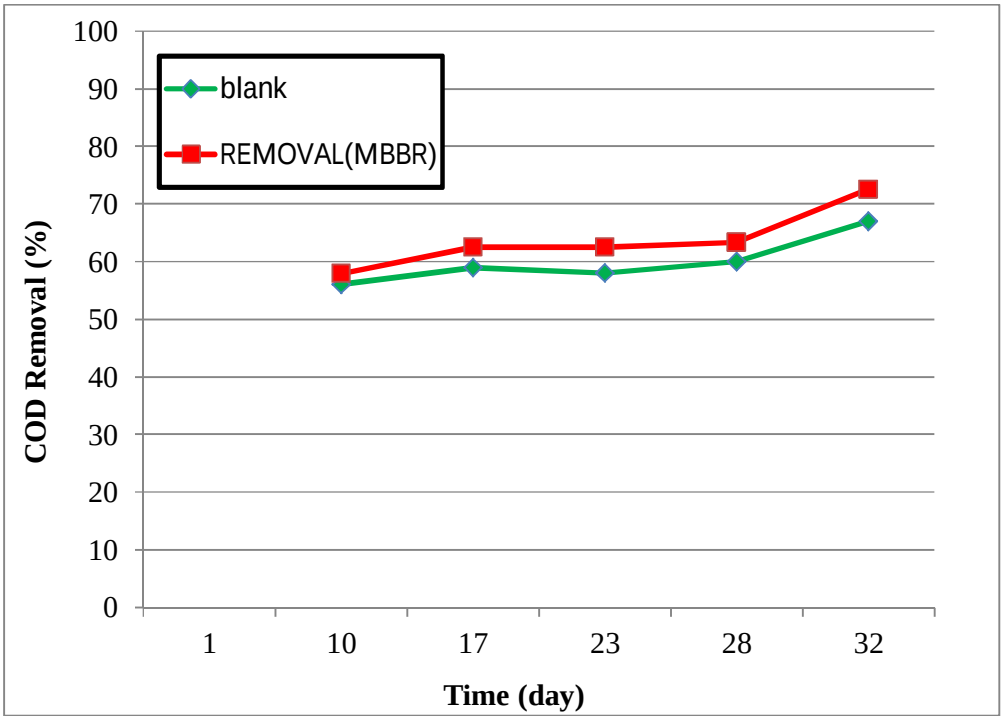

Diagram 8: Diagram of COD removal efficiency and its comparison with the control sample at the retention time of 8 hours

At this retention time: F/M=0.23, SRT=16.86, SVI= 27.69، MLSS=1133.
Average MLSS was 1133 mg/L in this stage, showing a big increase in comparison to the retention time 12 hour. F/M decreased from 0.39 to 0.23 which was the reason for the efficiency increase in this retention time.

4-3- retention time 5 hours.

As the retention time of aeration in the treatment plant was 5 hours, the pilot retention time was decreased to 5 hours (24 liter per hour) in order to determine the efficiency in this situation (diagrams 9, 10, 11 ,12).

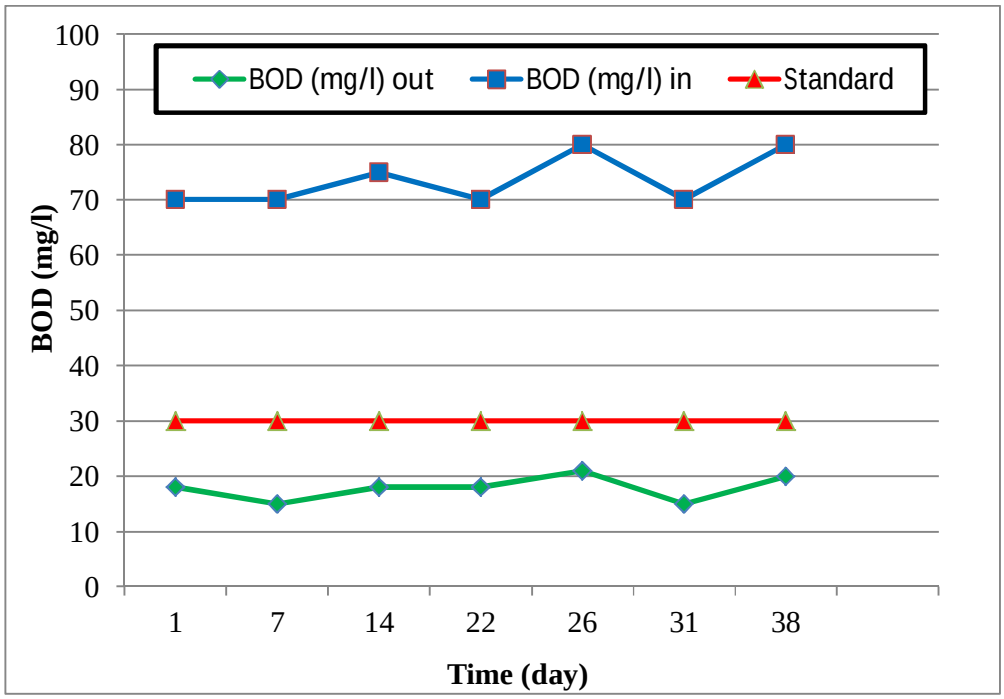

Diagram 9: BOD changes of MBBR inlet and outlet and their comparison with the standard sample at the retention time of 5 hours

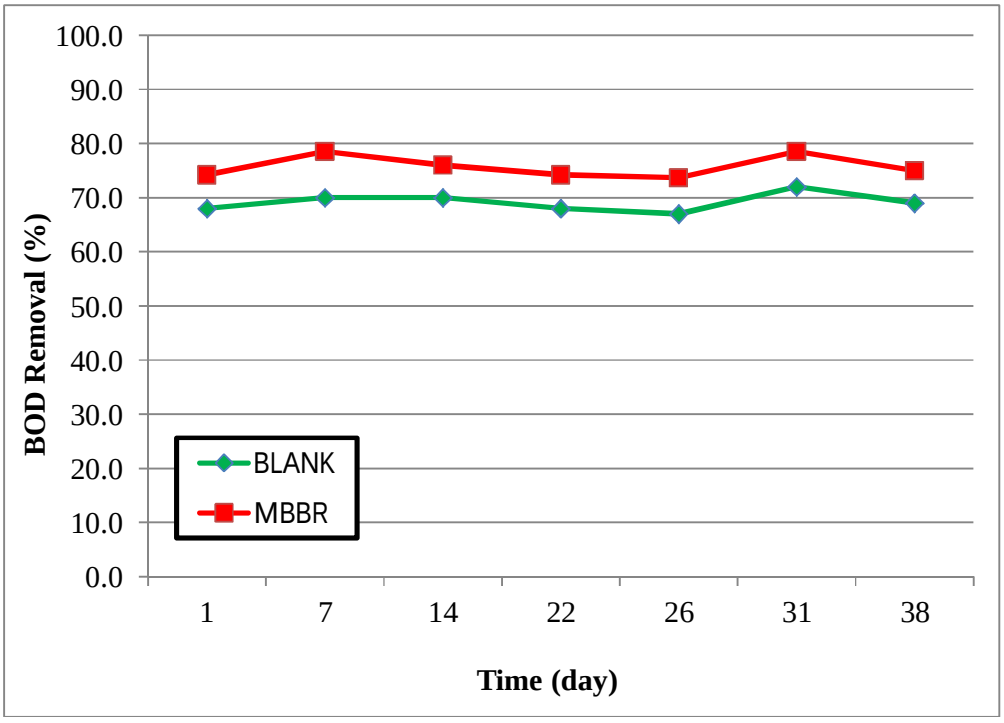

Diagram 10: BOD removal efficiency and its comparison with the control sample at the retention time of 5 hours

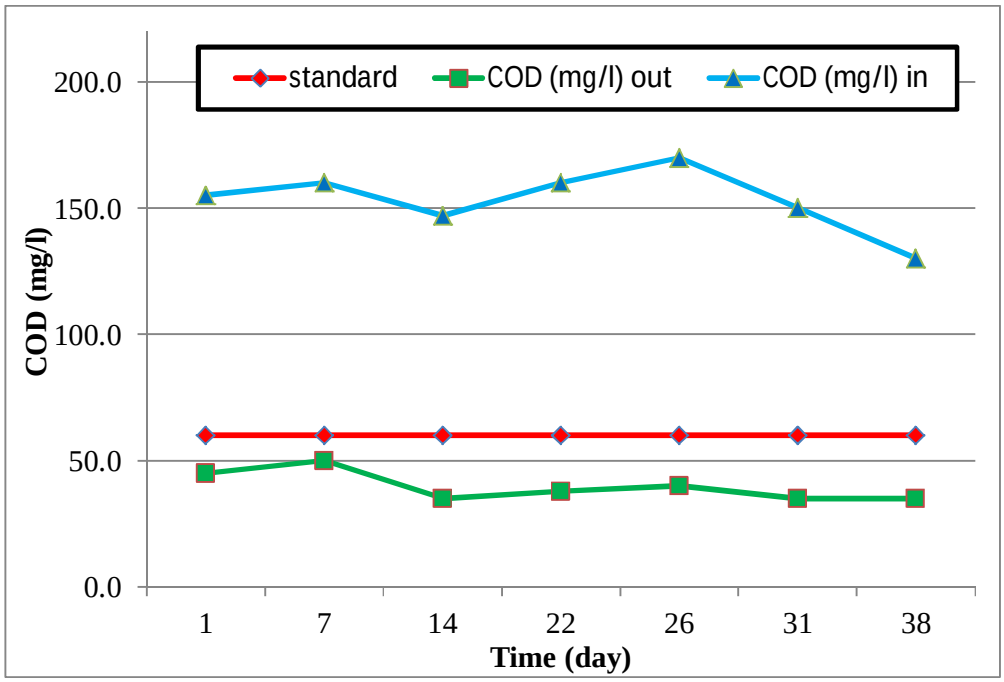

Diagram 11: COD changes of MBBR inlet and outlet and their comparison with the standard sample at the retention time of 5 hours

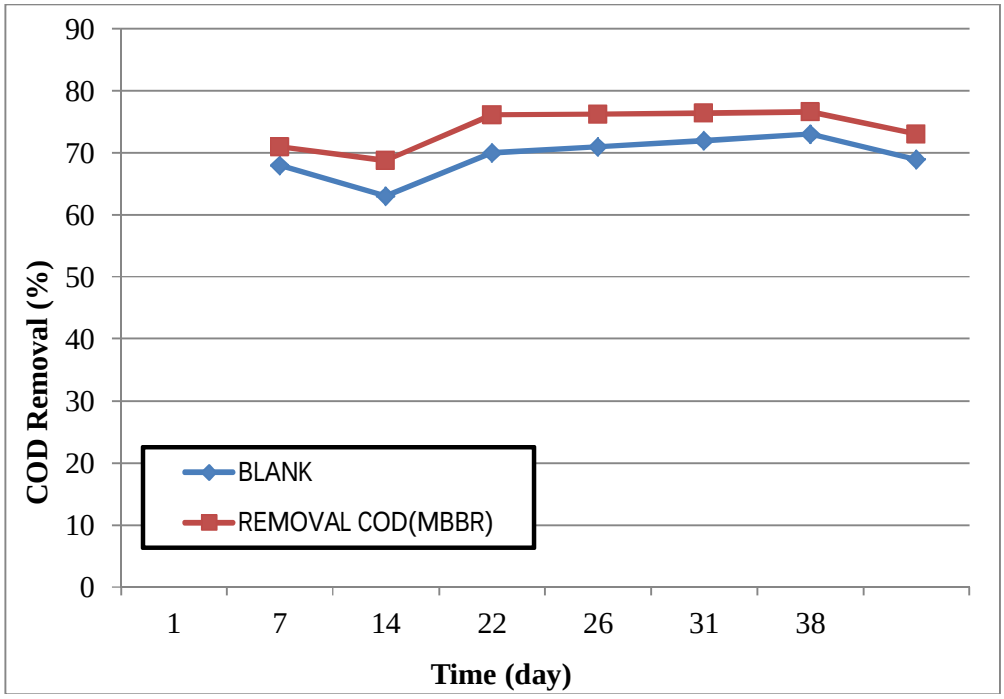

Diagram 12: COD removal efficiency and its comparison with the control sample at the retention time of 5 hours

according of the above diagrams it can be observed that at the retention time 5 hours, the inlet BOD average is 74 mg/L and the outlet one is 18 mg/L and the inlet COD average is 130 mg/L and the outlet one equals 35 mg/L. MBBR system shows BOD removal efficiency of 75.8% and this number for COD equals 73.45. The efficiency for MBBR increase equals 6.6% in comparison to the control sample. At this retention time, SRT =18.74 (day) DO = 3 mg/ L T= 27, MLSS =2029 SVI = 41 F/M=0.17

5- DISCUSSION

According to above graphs and mentioned figures it can be observed that at the first retention time 12 hours the job was done based on the stoical analysis and at certainly level of 95% (t-value1.41, sig=0.23).There is no meaningful difference between BOD removal efficiency in MBBR system and ordinary activated sludge .At the retention time 8 hours and according to the statistical analysis and at certainly level of 95%(t-value =1.91, sig=0.11), there is no meaningful difference between MBBR system BOD removal efficiency and the control one. At the retention time 5 hours and according to statistical analysis with a 95% certainly level (t-value =7.83, sig=0.00) there is a meaningful difference between MBBR system BOD removal efficiency and the control one.

At the retention time 5 hours the efficiency should be reduced compared to the past as the lower retention time means the higher discharge, but according to the graphs, the efficiency increases because of the following reasons.

At the retention time 12 hours the temperature was about $14c^0$, but at the time 5 hours it reached $27c^0$ leading to an activity increase in microorganisms and an improved efficiency. At the retention time 12 hours, SVI system was about 20, but at the time 5 hours, it reached about 40. The low SVI leads to the formation of ping point flock which reduces the system's efficiency. By comparison of F/M ratio at the retention time of 12 hours (0.39) and the retention time of 5 hours (0.17) it is determined that the system has recently been stabilized and as a result, the efficiency has increased .The dissolved oxygen is reduced at this retention time, reaching 3 mg/L which seems proper for the system. Therefore, it was necessary to restart the system at the time 12 hours which increases the efficiency to about 82% to choose the retention time both high efficiency and technical, economical parameters should be considered. At the retention time 5 hours we can see more wastewater entering the system, more wastewater treated with less energy and a fixed volume. Further, the needed standards for the environment are met for which the retention time 5 hours is chosen as the efficient time at which MBBR system retention time shows a 7% increase in BOD efficiency compared to the control one. The reason for the low difference of MBBR efficiency compared to the control one is the low inlet organic load which makes the biofilm to have a little thickness and SRT does not increase either. Under any condition, it has a higher efficiency than the ordinary activated sludge.

In a study, GOW.NGO.H.H was done with the polyurethane media and with 400 inlet COD. The removal efficiency was 100 for phosphorus (16). In a study done waste water landfill with1000 inlet COD, COD removal efficiency was 91 %. (17). Media were made of PVC pipes in this study. In another study done on pesticides with Kaldnes media the removal efficiency was 85% (18). In a study done in 2002, using the MBBR reactor in treating the slop of a pulp factory, the COD removal efficiency was 85 to 95 percent (19). Using this system in printing industry and at the retention time 5 hours showed an 85to 95 percent of efficiency for BOD (20). Using this system in dairy products shows 80% of efficiency (21) and in meat industry the efficiency was 50 to 70 percent in BOD removal. In these studies, the media were of Anoxkaldnes type (22, 23). In a study to treat Aniline in an activated sludge treatment plant at the retention time 13 hours and the cellular retention time 13 days ,the removal efficiency was 95(24). The removal efficiency was 92% in a municipal treatment plant with 231 inlet COD. The media was of flocor-RMP type in this study (25).

The reactor for outlet wastewater treatment of a big butchery, showed the efficiency of 90 and 60 percent at two different times (26).

MBBR system has been used in the outlet wastewater treatment of a wood and paper company .In this study, with an industrial scale, two MBBR systems, along with a primary settling in a period of 6 months, showed 76 percent of efficiency for COD and 87 percent for BOD (27).In a different study for paper production, the efficiency equaled 65%for COD (28).

Having compared the above results with those of other performed studies, it can be observed that in other studies the results were different due to the combination and density of the inlet wastewater reactor filling percent, media type and the environmental condition of the pilot. As the inlet wastewater was a mixture of sanitization and surface wastewater and also because it was really watery, the structure biofilm layer seemed to be really thin and the removal efficiency was lower than the similar results.

6- CONCLUSION

Finally, we were able to improve a cheap and convenient treatment system, using the MBBR system with the Electrical corrugated duct media. This system showed a higher efficiency against ordinary activates sludge with the removal of COD and BOD.

In this study as there is a little difference between the removal efficiency in two used MBBRs, it is not economical under the low chemical load. Different studies show that extreme air feeding makes the formed biofilm loose. Too many Waves make the biofilm layers loose and it is much better to install the system at a high retention time. The system is insistent against the shocks.

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