Int. J. Environ. Res., 6(1):129-138, Winter 2012
ISSN: 1735-6865

Study on High-strength Anaerobic Landfill Leachate Treatability By Membrane Bioreactor Coupled with Reverse Osmosis

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Received 8 Feb. 2011; Revised 29 June 2011; Accepted 14 July 2011

ABSTRACT: One of the most important concerns in Tehran municipal landfill is the production of leachate and its potential for water resources pollution, this study was undertaken to examine feasibility of biological and physico/chemical treating of high-strength landfill leachate that was collected from Tehran municipal landfill. Average COD of the leachate in aerobic submerged membrane bioreactor is 68000 mg/L. The reactor with a working volume of 175 L, having membrane module (Hollow fiber) with pore size of 0.1 µm coupled with reverse osmosis with pore size of 0.001 µm was used in this study. The dissolved oxygen (DO) concentration was maintained at 3.2 mg/L and solid retention times (SRTs) and hydraulic retention times (HRT) were controlled at 55 and 15 days respectively. the average Membrane Bioreactor effluent COD was 1733 mg/L with average removal efficiency of 97.46%. The average NH4 –N removal efficiencies was 99%. On the other hand, an almost complete nitrification was achieved during this period. PO_4 –P concentration in the effluent was low and its average removal efficiency was as high as 90%; especially during the operation period. The averages reverse osmosis (RO) effluent COD was 335 mg/L with average removal efficiency of 99.13%. PO_4-P concentration in the RO effluent was 0.86 mg/L and its average removal efficiency was 99.33%. The use of Membrane technologies, more especially reverse osmosis offers the best solution of achieving full purification with average COD removal efficiency of 99% and solving the problem of water resources pollution.

Key words: Municipal solid waste, Hollow fiber, MBR, RO, Nutrient removal

INTRODUCTION

The method of anaerobic sanitary landfill for the disposal of municipal solid wastes continues to be widely used in the most countries in the world (Bilgili, *et al.*, 2003; Renou, *et al.*, 2008; Hongjiang, *et al.*, 2009). The major long term problems caused by landfills are related to the generation of leachate which can cause considerable environmental problem.

Leachate is a high-strength wastewater formed as a result of percolation of rain-water and moisture through waste in landfills (Hasar, *et al.*, 2009). During the formation of leachate, organic and inorganic compounds are transferred from waste to the liquid medium(Bohdziewicz, *et al.*, 2008) and pose a hazard to the receiving water bodies. Production of landfill leachate begins with introducing moisture waste into disposal area and continues for several decades following the landfill closure. Leachate contains high organic matter and ammonium nitrogen and varies from site to site and its composition depends upon the landfill age, the quality and quantity of waste, biological and chemical processes that took place during disposal, rainfall density, and water percolation rate through the waste in the landfill. Depending upon what was placed in the landfill, leachate may contain many types of contaminants, and if not removed by treatment, these contaminants may be toxic to life or simply alter the ecology of receiving streams. leachate should be treated before reaching surface water or ground water bodies, because it can accelerate algae growth due to its high nutrient content, deplete dissolved oxygen in the streams, and cause toxic effects in the surrounding water life. Since the composition of a leachate consists of a wide range of contaminants, it cannot be easily treated by conventional methods. Therefore, a number of scientists around the world have intensively focused

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on the combination of biological and physico-chemical treatment systems for effective leachate treatment (Canziani, *et al.,* 2006; Hasar, *et al.,* 2009).

Alternative treatments have been reviewed. Briefly, leachate can be recirculated to the same landfill or treated by different methods: biological, aerobic, anaerobic methods and/or nitrification–denitrification to remove organic matter and ammonium nitrogen. Biological processes to remove organic matter can be effective for young leachate with a high BOD5/COD ratio (Maranon, *et al.,* 2008). Many researchers reported that the membrane bioreactors are effective treatment alternatives for the young leachates(Hasar, *et al.,* 2009) Landfill leachate is characterized by its generation rate and composition, both of which are affected by the age of the landfill site(Bodzek, *et al.,* 2006). In particular. Leachate consists of many different organic and inorganic compounds that may be either dissolved or suspended and which are biodegradable and non-biodegradable (Bodzek, *et al.,* 2006). In addition to this, the characteristic of the leachate varies with regard to its composition and volume, and biodegradable matter present in the leachate with time. For this reason, young and old landfill leachates have very different features. Calace et al. reported that the young landfill leachate fractions have low molecular weight distributions (<500 Da) at the rate of 70%, while the high molecular weight distribution (>10,000 Da) is 18%. Besides, the low and high molecular weight distributions are 28 and 67%, respectively, in old landfill leachate samples (Bilgili, *et al.,* 2003). According to this result, easily biodegradable components of leachate reduce, and constituents having high molecular weights and that are nonbiodegradable increase in the course of time. These factors make leachate treatment difficult and these factors are needed to be taken into account when different treatment processes are considered. The treatment requirements for leachate from sanitary landfills can vary depending on the discharge limits and contaminants present. An effective method for the treatment of leachate is recirculation through the landfill. When leachate is being recirculated, the constituents attenuated by biological activity and by other chemical and physical reactions occur within the landfill. At present, collection and treatment of landfill leachates are issues surrounding the operation of landfill sites (Bilgili, *et al.,* 2003).

Among advanced biological treatment processes, membrane bioreactor (MBR) is the most important process (Hasar, *et al.,* 2009). MBR are considered as a good integration of conventional activated sludge (CAS) system and advanced membrane separation, thus enabling the independent control of sludge retention time (SRT) and hydraulic retention time (HRT) and retaining a high concentration of sludge biomass in the reactors. Compared with CAS processes, MBR process has great advantages including a smaller footprint, less sludge production and better effluent quality (Wang, *et al.,* 2008).

MBR can be operated at very long sludge ages and can extend greatly the field of application of biological processes for concentrated streams, such as leachate (Canziani, *et al.,* 2006), The combination of membrane separation technology and bioreactors has led to a new focus on wastewater treatment. It contributes to very compact systems working with a high biomass concentration and achieving a low sludge production with an excellent effluent quality. Membrane bioreactors have been widely applied at full scale on industrial wastewater treatment and some plants have been adapted to leachate treatment (Van Dijk, *et al.,* 1997; Renou, *et al.,* 2008). The process efficiencies were in the range of 95–98% in terms of TOC reduction, and exceeded 97% for specific organic pollutants. Contrary to conventional systems, organisms such as nitrifiers or organisms which are able to degrade slowly biodegradable substances are not washed out of the system and no loss of process activity occurs (Renou, *et al.,* 2008).

RO seems to be one of the most promising and efficient methods among the new processes for landfill leachate treatment (Renou, *et al.,* 2008).

The recent studies on leachate treatment results in Iran showed that anaerobic reactor with detention time of 3 days had a 35% COD removal and increasing the detention time to 4.5 days would improve the COD removal to 45%. Nutrient adjustment with phosphorus and nitrogen increased the initial 23% efficiency of sequence batch reactor to 44%. The effluent COD of SBR reactor was 21,309 mg/L. Recycling of aerobic reactor effluent with incoming feed to anaerobic reactor reduced the anaerobic reactor influent COD to 20,000 mg/L and this caused 53% and 57% COD removal in the anaerobic and aerobic effluent, respectively. The total systems COD performance increased to 80% and SBR effluent COD evetually reduced to 4,000 mg/L (Torabian, *et al.,* 2004) and in the other study in shiraz landfill was found that a combined anaerobic digesters and an activated sludge rector system had 83-94% COD removal efficiencies (Kheradmand, *et al.,* 2010).

MATERIALS & METHODS

The leachate used in this study was collected from a municipal landfill located in Kahrizak near Tehran city in the Tehran province. The landfill has been in operation since 1985, the age of landfill for sampling is 0.5-1 years old. The large volume samples (200 L) were collected and stored in a retention tank every week.

The characteristics of the landfill leachate investigated are shown in Table 1. Leachate used during this study was young because it contained readily biodegradable organic matter (Hasar, *et al.*, 2009).

Table 1. Average quality of landfill leachate used as fed

Parameter	Values
COD, mg/L	68250±8000
BOD, mg/L	44500±3000
NH3+NH4-N, mg/L	1470±90
NO3+ NO2-N, mg/L	150±50
pH	6.9±0.2
PO4-P, mg/L	130±40
BOD/COD	0.65
COD/NH4-N	46.42
COD/PO4-P	455
Cl-, mg/L	14800±1000
SO4, mg/L	5500±300
Conductivity, µmhos/cm	44150±4500
Turbidity, Ntu	190±8.4

process configuration and system design

The investigations were carried out at a laboratory scale in a MBR reactor. The reactor with a working volume of 175 L was made of Plexiglas. Dissolved oxygen was supplied using 2 fine bubble disc diffusers (ecoflex 250 cv). Made by USA diffuser tech co. Placed at the bottom of the reactor, producing bubbles of pour size. The amount of oxygen supplied to the reactor was regulated in order to maintain the oxygen concentration at a level of 3 mg/L, one blower pump with capacity of 190 m3/h and pressure of 320 mbar, supplied system air requirement, an adjustable air valve controlled.

To startup the reactor, the seed of returned activated sludge of Gitarieh wastewater treatment plant was used and the seed was added with the volume of about 20 L per MBR with volume of 175 L and VSS of 1500 mg/L. After each time of aeration rates changes we gave minimum 55 day(SRT) to system to adapt with new condition, Sludge abstraction directly from the MBR leads to a method of control of the SRT (called the Hydraulic control of SRT)that was used in this study, The sludge age, in days, is defined by equation number 1,

$$SRT = \frac{X V_p}{X q} = \frac{V_p}{q} \qquad (1)$$

Where

V_p = volume of the process reactor (L)

q = volume of mixed liquor to be wasted (L)

Analysis were done, when the system reached steady state condition, MLSS at the end of operation in the reactor assumed as the steady state index, samples were taken from feed and treated leachate, samples were stored in polyethylene cap bottles with capacity of about 100 ml, temperature and dissolved oxygen is measured online air volumetric flow rate in aeration reactor was measured by a volumetric contour in a defined time.

Due to importance of timely stages control in MBR system as well as setting feeding, vacuuming, backwashing and measuring and recording of dissolve oxygen and temperature a PLC and computerized system with essential accessories, which includes control and relay boards, dissolved oxygen and temperature probes, electrical valves, feed pump were used. Fig. 1 present, schematic, system which had a working volume of approximately 0.175 m3, in which the membrane module was directly submerged, as shown in Fig. 2. The dissolved oxygen (DO) concentration was maintained at 3.2 mg/L by adjusting the air flow to 4 m3/h, the recorded data DO concentration shown in Fig. 2. The water level in the bioreactor was controlled with a level controller and a level sensor. The concentration of the mixed liquor suspended solids (MLSS) was 6300 mg/L. The sludge was withdrawn continuously with a pump set at different solid retention times (SRTs). HRT was controlled at 15 days by a rotary flow meter under the operational condition of invariable membrane flux, The effluent of the bioreactor was connected to an automatic vacuum effluent system directly by a rotary flow meter. When the vacuum pump started, part of the gas in the MBR was pumped out to create a negative pressure, and then the wastewater in the bioreactor was drained out through the membrane module and entered into the treated wastewater tank. Backwash electrical gate valve (1 minute in 1 hour) and vacuum pump (3 minutes in 1 hour) periodically run in the automatic vacuum effluent system. However minimum vacuum level was kept by a floater, whether feeding or vacuum pumps were operating or not. Therefore, wastewater entered the bioreactor noncontinuously through the flow into the submerged membrane module. Feeding pump operates noncontinuously at operating time.

Consider the disposal of excess sludge from the aeration tank mixed liquid, where sludge age according to reactor volume and flow of liquid mixtures were determined. In the first step to adjust the sludge age of 15 days, 12 L/day of MLSS were abstracted directly from the MBR, 30 days were exploited in this case due to excessive floor production and half of the volume of overflow to the reactor, in the second step 6 L/day of MLSS were abstracted and the sludge age was set at about 30 days, during 60 days of operation due to the production floor was no steady state, in the third step removing 4.5 L/day of MLSS the sludge age was

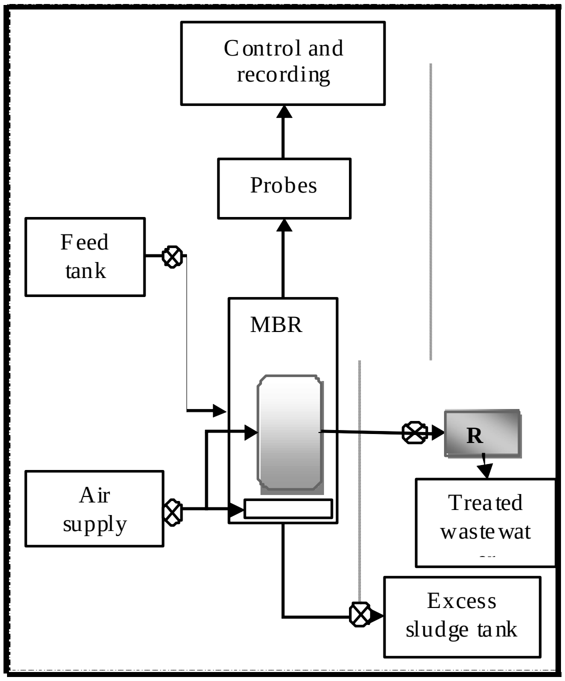

Fig. 1. Schematic diagram for MBR process

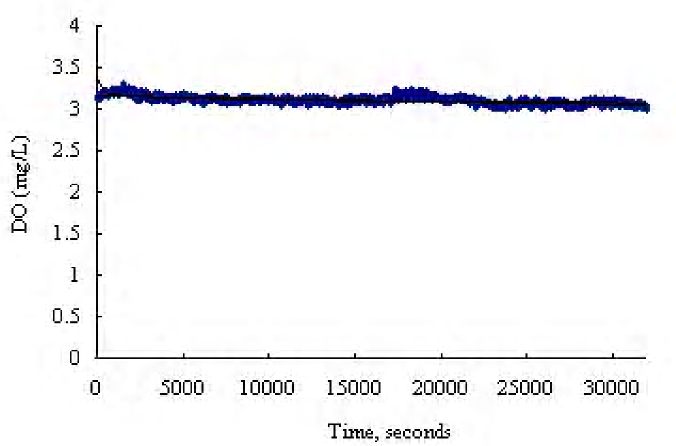

Fig. 2. Part of DO Concentration Recorded data in the MBR

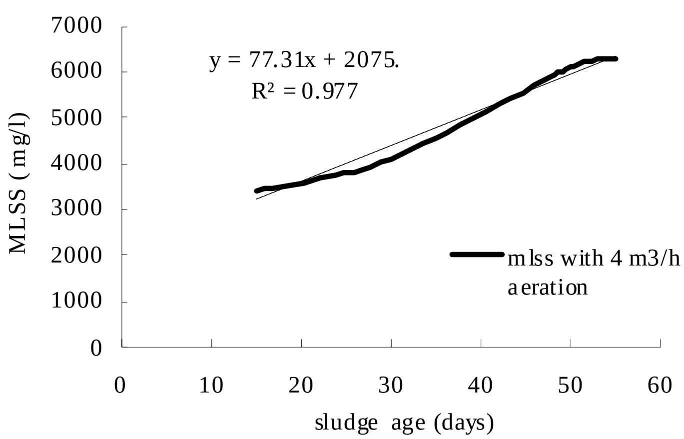

Fig. 3. MLSS relation to Sludge age

set at about 40 days, in this mode of operation 80 days after the production floor in a relatively acceptable level of control relatively stable conditions were achieved, by adjusting the final step in the sludge age of about 55 days and 3.2 L/day disposal of MLSS after 100 days the conditions were quite stable in the MBR and the amount of MLSS inside the reactor, about 6300 mg/L remained stable at this time of vulnerability analysis, leachate treatment by the reactor was initiated. Curve in fig. 3. Changes to the the MLSS and sludge age is given.

In this pilot-plant test, a hollow-fiber pp microfiltration (MF) membrane was used with pore size of 0.1µm and the effective surface area of a MF membrane module at 4m2. Membrane flux was between 0.5 and 0.8 m3/d. (Table 2).

Table 2. Technical data of poly propylene Hollow Fiber

Parameter	Hollow fiber
Raw material	PP
Diameter inside	320- 350µm
Diameter outside	400-450µm
Pore size	0.1-0.2µm
Pore density	40-50%
Membrane area	4 m2
Pressure minus	0.01-0.03 Mpa
pH	0 -14
Available temp.	4 -45 °c

The RO membrane used in the process was a Filmtech TW30-1812-100 Membrane (DOW, USA). The unit was installed at the lab and it was designed to run at a constant operation pressure. The RO technical characteristics are presented in Table 3.

Table 3. Technical data of Reverse Osmosis

Parameter	Reverse Osmosis
Membrane type	Polyamide thin-film composite
Applied pressure	3.4 bar (50 psig)
Permeate flow rate	16 L/h
Stabilized salt rejection	98%
Max operating temperature	45 °c
Max operating pressure	21 bar
Max feed flow rate	7.6 L/min
pH range, continuous operation	2-11

A lab-scale MBR was set up for COD and biological nutrient removal with a flow rate of 12 L/day. and operated under a total SRT of 55 days, and an HRT of 15 days. Influent characteristics were measured for 3 months. The effluent BOD5, COD, NO3-N, and PO4-P, NH4-N, NO2-N, EC, turbidity, Cl-, SO4 were monitored for six weeks. All experiments were conducted under conditions of constant temperature (21 C°) and controlled pH (9.5).Determination of COD, BOD5, nitrite, nitrate, ammonium, phosphate, sulfate, CL-, conductivity, MLSS and turbidity were performed according to standard methods, 20th ed. Were used for measurement of total solids (TS), ammonia nitrogen (NH4), chloride, total alkalinity and pH. Chemical oxidation demand was analyzed colorimetrically using tests and photometer of the HACH firm (DR 2010).

RESULTS & DISCUSSION

MBR was run for approximately 11 months. In this work the attention was specifically focused on the mechanisms of nutrient removal on MBR unit with high aeration ratio (4 m3/h), in these study seven parameters (COD, N-NH4, P-PO4, CL-, SO4-, Conductivity and turbidity) were investigated.

The removal of COD from wastewaters has been under investigations by many researchers in different methods. COD discharge standard in Iran is 200 mg/L. In the work of Renou et al. (Renou, *et al.*, 2008), the removal percentage of TOC and COD were achieved up to 95–98%, and 90% respectively in a proper operation of MBR_s. In this regards, Torabian et al. (Torabian, *et al.*, 2004) and S. Kheradmand et al. (Kheradmand, *et al.*, 2010) who examined anaerobic and aerobic reactors in COD removal, total systems, performance increased to 80% and 83-94%, respectively. In order to efficiently achieve discharge limit criteria, proper methods should be used. Membrane Bioreactors could be a suitable method for achieving this target.

The average COD concentrations in the influent are 68000 mg/L. During the operation, removal efficiencies of COD were above 97.0% suggesting that it was irrespective of COD/N ratios. With high COD/N ratio of 45, the nutrient requirements decrease as the sludge age increases because net sludge production decreases as sludge age increases generally, for sludge ages greater than 10 days, the nitrogen removal attributable to net sludge production is less than 40 mg COD/mg N applied (Marais, 1994). The maximum value for percent COD removal was obtained around COD/P-PO4 =160 and then dropped above 160 indicating phosphate limitation at high COD (Kargi, *et al.*, 2003). Increasing COD/N-NH4 ratios from 10 to 50 possibly resulted in decreases in COD steadily removal of efficiencies because of ammonium and PO4 limitations at high COD/N-NH4 and COD/P-PO4 ratio (Kargi, *et al.*, 2003). in this study the sludge age (SRT) regulate at 55 days then the MLSS was stabilized at 6.3 g/L, Despite the fluctuations of average influent COD concentration ranging from 60000 mg/L to 75000 mg/L, the effluent COD concentrations were always lower than 1935 mg/L. as shown in Fig. 4, The average effluent COD concentrations was 1733 mg/L, with the average efficiency of 97.46%, under COD/N ratio of 46 and COD/PO4-P ratio of 455 and BOD/COD ratio of 0.65 These

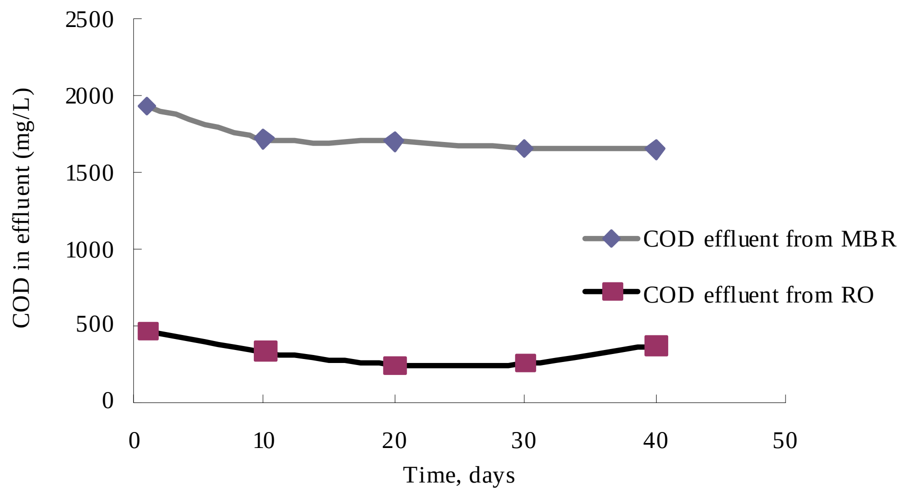

Fig. 4. COD concentrations in the MBR and RO effluent

data indicated that the system could provide a consistent high efficiency of COD removal.

The removal of NH4-N from leachate streams has also been a subject of research by many investigators (Renou, *et al.*, 2008). Typical discharge standard in Iran is 2.5 mg/L. removed 80% of TKN in a proper operation of MBRs. Using this method, removal percentage of NH4-N was reached over 97% by N. Laitinen et al. (Laitinen, *et al.*, 2006) In other research which was performed by S. Kheradmand et al. in Iran, total system' NH4-N performance increased to 64.7% (Kheradmand, *et al.*, 2010).Removal efficiency for ammonium-nitrogen increased with COD/NH4-N ratio between 10 and 40, because of high ammonium concentrations at low COD/NH4-N ratio, ammonium removal efficiencies were low (Kargi, *et al.*, 2003). Increasing COD/PO4-P ratio resulted in steady increases in NH4-N removal efficiencies for COD/PO4-P values between 40 and 250 indicating adverse effects of high phosphate levels or COD limitations at low COD/PO4-P values (Kargi, *et al.*, 2003).

During the whole operation, the removal efficiencies of NH4–N and TN were as good as COD removal, as shown in Fig. 5. During the operation, COD/N is 46.42, the NH4 –N and TN concentrations removal in effluent were almost the same, indicating no NOx –N accumulation observed in the reactor. Produces of nitrification were almost completely denitrified to nitrogen gas. The average NH4 –N and TN removal efficiencies were 99% while the average NH4 –N effluent concentrations were 10 mg/L, initially, nitrification activity increased gradually, and the highest NH4 –N removal efficiency was 99.7%. However, an almost completely nitrification was achieved during this period.

These data showed that 40.55 mg/L NOx –N was remained after 30-40 days, which implying that the denitrification was accomplished completely.From 20 d to 40 d, the effluent NH4 –N concentration was increased to above 10 mg/L, Initially, the effluent NH4 –N and TN concentrations increased drastically, due to that the microorganism need a period to acclimate the change. Afterwards, effluent concentrations were decreased gradually, suggesting that the nitrification and denitrification capacities were strengthened gradually.

Removal of PO4-P has also been investigated by many investigators in the last decade. They applied different aeration ratio as the removal technique. Laitinen et al. reduced phosphorus concentration over 88% by this method (Laitinen, *et al.*, 2006). In the other works of Torabian et al. in Iran 90% of phosphorus was reduced in a proper operation of systems (Torabian, *et al.*, 2004). However Typical discharge standard for PO4-P in Iran is 6 mg/L.

Increasing COD/PO4-P values from 40 and 160 resulted in increases in phosphate removal efficiency. Because of excess phosphate or COD limitations at low COD/PO4-P values the phosphate removal efficiency was low. The efficiency decreased for COD/PO4-P values above 200 because of phosphate limitations at high COD/PO4-P values (Kargi, *et al.*, 2003).

Fig. 6 presents the PO4 –P concentrations in the effluent during the whole operation period. With COD/PO4-P ratio of 455, although the PO4 –P concentration in the effluent was low and the average PO4 –P removal efficiency was as high as 90%.with increasing COD/N ratio, the PO4 –P concentrations in anoxic and aerobic zones decreased insignificantly, and effluent concentration between 1d and 20d was as high as 23.25 mg/L and the average PO4 –P removal efficiency was 85.3%, especially during operation period The PO4 –P removal process was stabilized between 20 d and 40 d, with average PO4 –P effluent concentration of 6.1 mg/L and removal efficiency of 96%. Additionally,

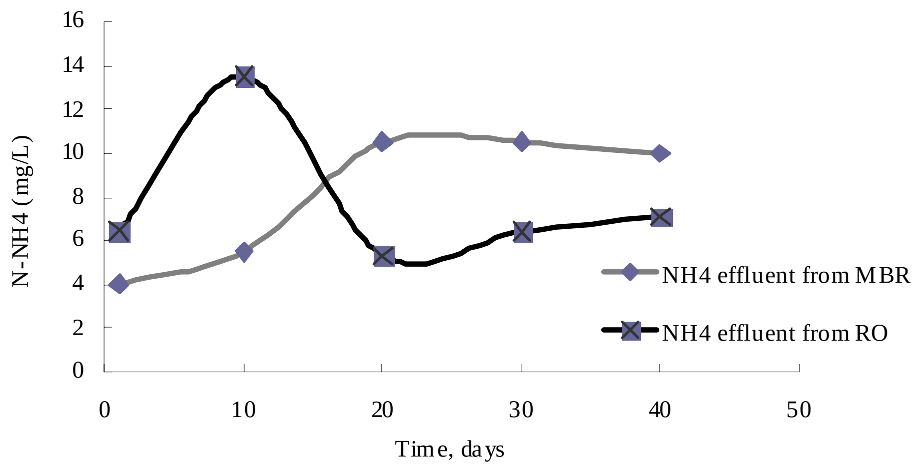

Fig. 5. N-NH_4 concentrations in the MBR and RO effluent

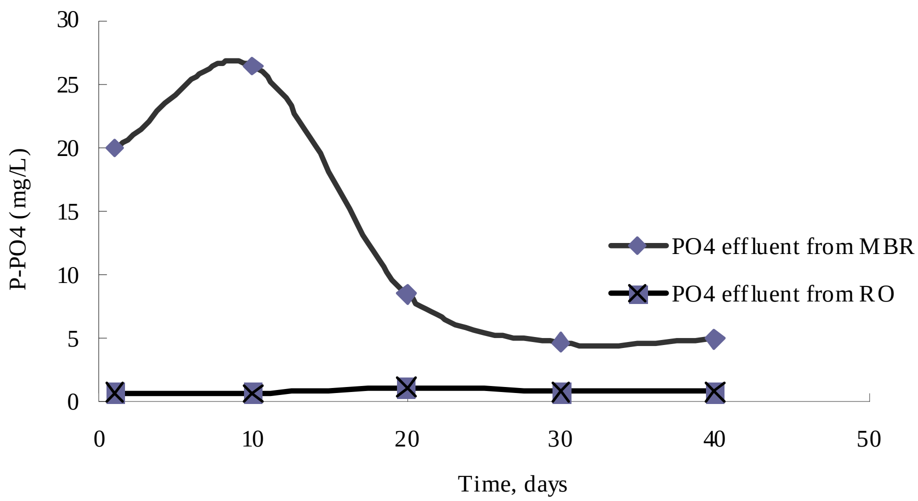

Fig. 6. P–PO_4 concentrations in the MBR and RO effluent

PO4 –P release process ceased in anoxic zone. Results indicated that low COD/N ratio decreased PO4 –P removal efficiency. And increasing sludge age increasing the PO3_4 –P removal efficiency.The other objectives of this research were focused on the evaluation of the pilot scale operation and monitor of an MBR system to treatability of landfill leachate and the removals of certain pollution parameters such as CL-, SO4-, EC (electrical conductivity) and turbidity that were monitored.

After the membrane bio-reactor was run for two months, the treatment efficiency of the MBR stabilized. The operation of the bio-reactor was monitored to provide an insight into its efficiency in reducing the concentrations of CL-, SO4-, EC (electrical conductivity) and turbidity in this leachate. Experiments for the MBR with the first feed have indicated that total CL-, SO4-, EC (electrical conductivity) and turbidity removals were 42%, 62%, 7.9% and 78% respectively. The influent CL-, SO4-, EC (electrical conductivity) and turbidity values were reduced to 8620 mg/L, 2060 mg/L, 40680 µmhos/cm and 826 Ntu from the MBR at a pressure of 2 bars. Fig. 7, 8, 9, and 10 presents the CL-, SO4-, EC (electrical conductivity) and turbidity concentrations in the effluent during the whole operation period.

The RO system is mainly used for further removal of suspended substances in the leachate and reduction of conductivity. The RO system operated continually at the membrane flux of 12 L/day. The removal of various pollutants by the MBR at HRT of 15 days is shown in Table 4. It shows that the MBR is effective at reducing turbidity, COD and conductivity, which is attributed to the combined effects of the substrate, microbial communities and plants in the MBR. The RO system operated under constant flow conditions for 41 days after the pretreatment of MBR. As can be seen from Table 4, after the pretreatment of MBR, COD, BOD, NH4-N, PO4-P, Cl^-, SO_4, conductivity and Turbidity in the water was reduced from 1733 mg/L, 270 mg/L, 8.1 mg/L, 12.94 mg/L,8620 mg/L, 2060 mg/L,

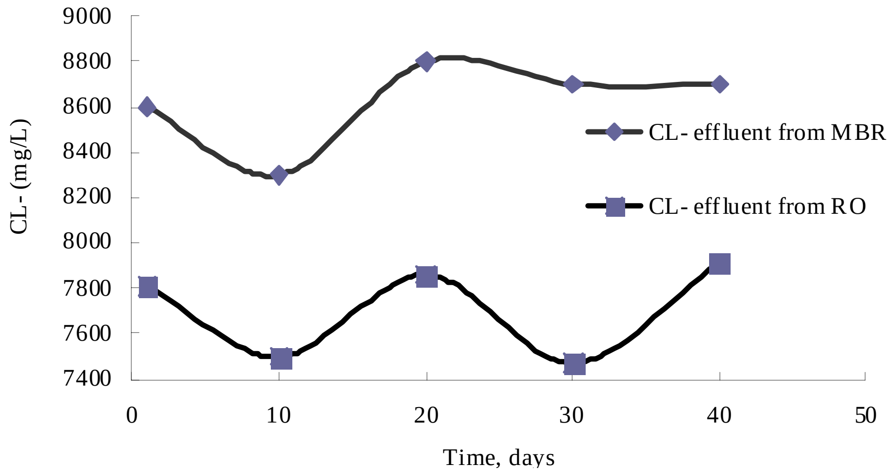

Fig. 7. Cl$^-$ concentrations in the MBR and RO effluent

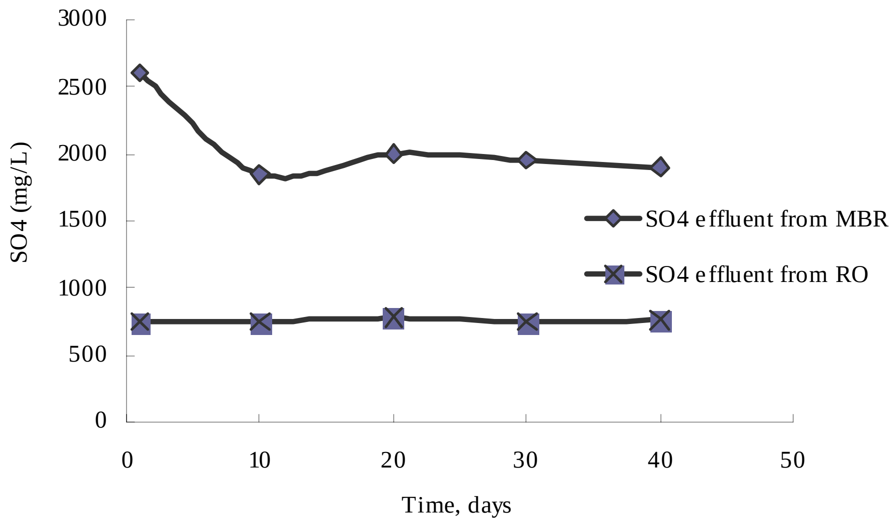

Fig. 8. SO_4^- concentrations in the MBR and RO effluent1

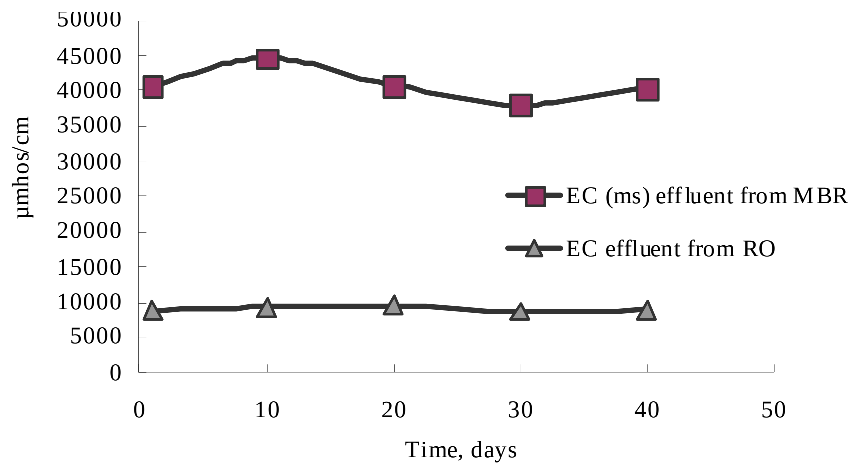

Fig. 9. EC in the MBR and RO effluent

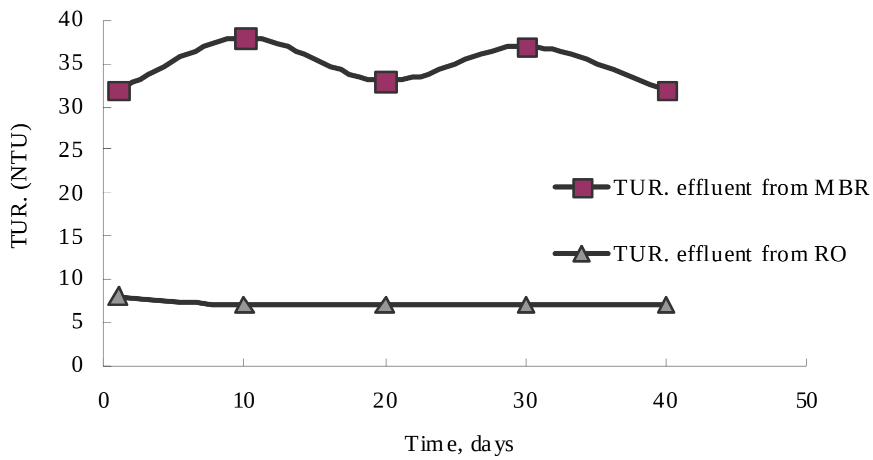

Fig. 10. Turbidity in the MBR and RO effluent

Table 4. Average ConcentrAtions and Removal Efficiency in the MBR

Parameter	Average Effluent from the MBR	MBR Removal Efficiency (%)	Average Effluent from the RO	RO Removal Efficiency (%)
COD ,mg/L	1733	97.46	335	99.13
PO4-P, mg/L	12.94	90.05	0.86	99.33
BOD, mg/L	270.8	99.39	62.5	99.85
NH4-N, mg/L	8.1	99.45	7.74	99.51
Cl-, mg/L	8620	41.76	7710	47.9
SO4, mg/L	2060	62.55	758	86.21
Conductivity, µmhos/cm	40680	7.85	9044	79.51
Turbidity, Ntu	58	78.8	7.2	96.36

40680 µmhos/cm and 826 Ntu, to 335 mg/L, 62.5 mg/L, 7.74 mg/L, 0.86 mg/L, 7710 mg/L, 758 mg/L, 9044 µmhos/cm and 7.2 Ntu, respectively. The advanced treatment of the mixed treated leachate from landfills with MBR/RO process is feasible, and the MBR proved to be a reasonable and effective pretreatment method for the RO system. The average reduction by the MBR of COD, BOD, NH_4-N, PO_4-P, Cl^-, SO_4, turbidity and conductivity, were 97.46%, 99.39%, 99.45%, 90.05%, 41.76%, 62.55%, 78.8% and 7.85%, respectively. This pretreatment reduced the loading on the subsequent RO system and substantially improved the water quality, the conductivity of the produced water was 9044 µmhos/cm, through a membrane fouling analysis, it was found that fouling on the RO membrane was mainly colloidal, caused by refractory organic compounds and some inorganic contamination. After 41 days of operation, only minor fouling was found on the RO membrane, which suggests that there is no need for chemical cleaning, and that fouling will not affect stable long-term operation.

CONCLUSIONS

The present study contains results of land fill leachate treatability by membrane bioreactor and reverses osmosis that is important for modeling, design, and operation of landfill leachate treatment MBRs and determination of discharge limits.

Suitable treatment strategy depends on two major criteria: 1. the initial leachate quality and 2. the final requirements given by local discharge water standards(Renou, *et al*., 2008) the presented data indicate that the landfill leachate composition has a significant effect on treatability, in the young landfills and composting units leachate that organics concentration (expressed COD), BOD/COD, pH, COD/NH4-N ratio is high. The membrane bioreactor has to operate with sludge age greater than 50 days, hydraulic retention times (HRT) 15 days. MBR was developed and demonstrated herein to treat landfill leachate. In order to evaluate the biological treatability of the landfill leachate, the removal efficiency of COD, NH4-N, PO4 –P, CL-, SO4-, EC (electrical conductivity) and turbidity were investigated, These data indicated that The system provided high removals in terms COD, NH4-N, PO4 –P, CL-, SO4-, EC (electrical conductivity) and turbidity removal equal to 97%, 99%, 90.5%, 42%, 52%, 79% and 78% respectively. However after treatment in the MBR. The average effluent concentrations of COD, NH4 –N, PO4 –P, CL- and SO4- were 1733, 10, 13, 8620 and 2060 mg/L, respectively, all of them over the permissible limit for IRAN discharge standards (COD < 200 mg/L, NH4 -N < 2.5 mg/L, PO4 –P< 6 mg/L, CL-< 600 mg/L, SO4- < 400 mg/L ,…), quality of the effluent from MBR system was not appropriate for discharging into receiving waters requiring an additional post treatment regarding polishing purposes.

The results of the RO treatment are summarized in Table 4; Effluent quality was very high with regard to all parameters studied. Effluent turbidity was below 8 NTU, nutrients that were detected in the RO effluent, all their concentrations were below the detection limit of Iran standards (with the exception of COD). The integrated treatment of MBR and RO provided a superb quality effluent, which may be available for several reuse applications. Integration of the two processes is easy, since the MBR effluent is devoid of particulate matter and can be introduced directly in the RO unit.

ACKNOWLEDGMENT

The authors thank the Islamic Azad University Tehran medical branch, Iran municipalities and rural organization and Tehran municipality for supporting the study.

REFERENCES

Ahn, W. Y., Kang, M. S., Yim, S. K. and Choi, K. H. (2002). Advanced landfill leachate treatment using an integrated membrane process. Desalination, **149**, 109-114.

APHA, (1998). American Public Health Association, Standard methods for the examination of water and wastewater, **20th** ed., Washington D.C.

Azimi, A. K., Hashemi, S. H., Bidhendi, G. N. and Mahmoodkhani, R. (2005). Aeration ratio effect on efficiency of materials removal in sequencing batch reactors. Pakistan journal of biological sciences, **8 (1)**, 20-24.

Bilgili, M. S., Demir, A., Akkaya, E. and Ozkaya, B. (2008). COD fractions of leachate from aerobic and anaerobic pilot scale landfill reactors. Journal of Hazardous Materials, **158**, 157–163.

Bodzek, M., Lobos-Moysa, E. and Zamorowska, M. (2006). Removal of organic-compounds from municipal landfill leachate in a membrane bioreactor. Desalination, **198**, 16-23.

Bohdziewicz, J., Neczaj, E. and Kwarciak, A. (2008). Landfill leachate treatment by means of anaerobic membrane bioreactor, Desalination, **221**, 559–565.

Canziani, R., Emondi, V., Garavaglia, M., Malpei , F., Pasinetti, E. and Buttiglieri, G. (2006). Effect of oxygen concentration on biological nitrification and microbial kinetics in a cross-flow membrane bioreactor (MBR) and moving-bed biofilm reactor (MBBR) treating old landfill leachate. Journal of Membrane Science, **286**, 202–212.

Fu, Z., Yang, F., Zhou, F. and Xue, Y. (2009). Control of COD/N ratio for nutrient removal in a modified membrane bioreactor (MBR) treating high strength wastewater, Bioresource Technology, **100**, 136–141.

Hasar, H., Unsal, S. A., Ipek, U., Karatas, S., C nar, O., Yaman, C. and K nac, C. (2009). Stripping/ flocculation/ membrane bioreactor/reverse osmosis treatment of municipal landfill leachate. Journal of Hazardous Materials, **171**, 309-317.

Hongjiang, L., Youcai1, Z., Lei, S. and Yingying, G. (2009). Three-stage aged refuse biofilter for the treatment of landfill leachate. Journal of Environmental Sciences, **21**, 70–75.

Kargi, F. and Uygur, A. (2003). Nutrient removal per formance of a five-step sequencing batch reactor as a function of waste water composition, Elsevier science ltd. Process biochemistry, **38**, 1039-1054.

Kheradmand, S., Karimi-Jashni, A. and Sartaj, M. (2010). Treatment of municipal landfill leachate using a combined anaerobic digester and activated sludge system. Waste Management, **30**, 1025–1031.

Klimiuk, E. and Kulikowska, D. (2006). Organics removal from landfill leachate and activated sludge production in SBR reactors. Waste Management, **26**, 1140-1147.

Kulikowska, D. and Klimiuk, E. (2008). The effect of landfill age on municipal leachate composition. Bioresource Technology, **99**, 5981-5985.

Laitinen, N., Luonsi, A. and Vilen, J. (2006). Landfill leachate treatment with sequencing batch reactor and membrane bioreactor. Desalination, **191**, 86-91.

Marais, G. V. R. (1994). Wastewater treatment by activated sludge process. Lecture notes. University of Cape Town. South Africa. International Institute for Infrastructural, Hydraulic and Environmental Engineering, the Netherlands.

Maranon, E., Castrillon, L., Fernandez-Nava, Y., Fernandez-M endez, A. and Fernandez-Sanchez A. (2008). Coagulation–flocculation as a pretreatment process at a landfill leachate nitrification–denitrification plant. Journal of Hazardous Materials, **156**, 538–544.

Ozturk, I., Altinbas, M., Koyuncu, I., Arikan, O. and Gomec-Yangin, C. (2003). Advanced physic-chemical treatment experiences on young municipal landfill leachates. Waste Management, **23**, 441-446.

Renou, S., Givaudan , J. G., Poulain, S., Dirassouyan, F. and Moulin, P. (2008). Landfill leachate treatment: Review and opportunity. Journal of Hazardous Materials, **150**, 468-493.

Torabian, A., Hassani, A. H. and Moshirvaziri, S., (2004).Physicochemical and biological treatability studies of urban solid waste leachate. International Journal of Environmental Science & Technology, **1 (2)**, 103-107.

USEPA, (1989). fine pore aeration systems. Design Manual. EPA/625/1-89/023.

Van Dijk, L. and Roncken, G. C. G. (1997). Membrane bioreactors for wastewater treatment: the state of the art and new developments, Water Sci. Technol., **35**, 35–41.

Visvanathan, C., Choudhary, M. K., Montalbo, M. T. and Jegatheesan, V. (2007). Landfill leachate treatment using thermophilic membrane bioreactor. Desalination, **204**, 8-16.

Wang, Z., Wu, Z., Mai, S., Yang, C., Wang, X., An, Y. and Zhou, Z. (2008). Research and applications of membrane bioreactors in China: Progress and prospect. Separation and Purification Technology, **62**, 249–263.