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Co-treatment of mixed municipal sewage and landfill leachates via the hydrolytic acidification–sequencing batch reactors–membrane bioreactor process

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ABSTRACT

It is difficult and costly to treat landfill leachate, but combining a certain amount of landfill leachate with proper scale of municipal sewage can reduce the burden of landfill leachate treatment in incineration plants, which can also supplement carbon source for municipal sewage plants with large amount of sewage and generally low C/N. In this study, the hydrolytic acidification (HA)–sequencing batch reactors (SBR)–membrane bioreactor (MBR) was employed to treat mixed municipal sewage and landfill leachate, and the effect of the system on pollutant removal and membrane fouling development was investigated without any physical or chemical cleaning of the membrane. The results of the average COD, TN, NH_3–N, total phosphorus, and turbidity removal rates of the HA-SBR-MBR process were 95.1%, 61.9%, 97.5%, 91.1%, and 99.2%, respectively, shown under the conditions of the leachate ratio of 0.17%, pH of 6.56–7.10, hydrolysis time of 12- and 6-h SBR operating cycle. Hence, the pollutant removal efficiencies and effluent quality of the HA-SBR-MBR system were found to be excellent under these conditions, and the membrane separation process enhanced the efficacy of the system. During the operation of the system, membrane modules were used to intermittently filter the supernatant during the late period of the settlement stage, which maintained the stability of the membrane's filtration performance. The membrane fouling rate developed slowly, and the total membrane filtration resistance increased from the original 2.34×10^{12} to $5.03 \times 10^{12}\ m^{-1}$.

Keywords: HA-SBR-MBR process; Landfill leachate; Membrane filtration resistance; Membrane fouling; Mixed municipal sewage

1. Introduction

The leachates produced by household waste in waste-to-energy (W2E) power plants are mostly fresh leachates, which generally contain high and widely varying concentrations of organic matter that is highly biodegradable and rich in ammoniacal nitrogen, as well as a diversity of heavy metals. The treatment of these leachates via a single technique is very difficult and involves high overheads and operating costs. Furthermore, single-technique treatments are often inefficient, and the associated leachate processing equipment is also difficult to maintain. Secondary pollution caused by the concentrates that are produced by these treatments is also a severe problem [1–3]. At present, there is

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no uniform standard for the treatment of W2E power plant leachates in China or other countries. The most commonly used procedure for this purpose is "pretreatment + biological treatment + advanced treatment". The processed leachate is then discharged or reused after the contaminant levels have been reduced to acceptable levels [4]. There have been many studies on combined leachate treatment processes centered around membrane bioreactor (MBR) technology [5–8], for example, biochemical treatment + MBR + membrane treatment, MBR + membrane treatment/physicochemical treatment, advanced oxidation + MBR + advanced treatment, and hybrid membrane bioreactor technology. However, the C/N ratios of municipal sewage in China are generally low, and there are still many problems in the current nitrogen and phosphorus removal processes. For instance, the efficiency of denitrification processes is rather inconsistent, and the processes that mediate nitrogen removal and phosphorus removal both compete for carbon. These problems lead the focus of research on the optimization of operation strategies for municipal sewage plants. Therefore, many scholars have carried out studies on advanced sewage treatment methods, as well as upgrades and modifications for currently existing sewage treatment plants; the results of these studies have been applied to good effect in real sewage treatment systems [9–12].

MBRs employ an efficient sewage treatment technology that is capable of producing excellent effluent quality, high activated sludge concentrations, and minimal amounts of sludge residue while maintaining a compact footprint. Using MBRs thus is one of the most promising nitrogen and phosphorus removal methods [13–15]. However, comparative analyses on the efficiency of SBRs and MBRs in isolation [16–18] show that a combination of MBRs with conventional nitrogen and phosphorus removal processes (e.g., SBR, A^2/O, intermittent-aeration activated sludge processes, oxidation ditch) greatly enhances the nitrogen and phosphorus removal efficiency for municipal sewage [19,20]. Adam et al. [19] combined A^2/O with MBR and achieved high activated sludge concentrations, good effluent quality, and low sludge yield while maintaining a small footprint. These results drove the development of the A^2/O-MBR process and increased the scaling of nitrogen/phosphorus removal processes for sewage treatment [21,22].

Although, in the case of both landfill leachate treatment and municipal sewage treatment MBRs have shown good practical application effect, they often involve high operating costs and are plagued by membrane fouling issues [23]. Yuan et al. [24] studied the efficacy of the combined up-flow anaerobic sludge blanket–membrane bioreactor (UASB-MBR) process for the treatment of leachates from a W2E power plant in Jiangsu province at a rate of 150 m^3/d. Their results demonstrated that the UASB process reduces the organic load of the landfill leachate, achieving a COD_{Cr} removal rate of 62.5%. Moreover, the MBR process proved to be very effective in removing ammoniacal nitrogen, keeping the effluent's ammoniacal nitrogen levels below 30 mg/L. Therefore, the UASB-MBR process was able to improve the water quality of the W2E power plant's leachates up to the third grade of the GB16889-2008 standard (Standard for Pollution Control on the Landfill Site of Municipal Solid Waste) at an operating cost of 3.16 $/m3. Zhang et al. [25] treated the leachates of a W2E power plant using a combined treatment process, which consisted of pretreatment via precipitation and hydrolytic acidification (HA) followed by high-efficiency expanded granular sludge bed digestion (EGSB), storage in an anaerobic tank, and finally an MBR-nanofiltration/reverse osmosis (NF/RO) process. In this way, they were able to reuse the effluent as a source of circulating cooling water while keeping the entirety of the process fully closed, without discharging any waste. In operation tests, they demonstrated that this process is stable and readily applicable for the treatment of W2E power plant leachates. The direct operating costs of this process (excluding labor costs, equipment depreciation costs and maintenance costs) were approximately 3.58 $\$/m^3$.

Due to the large amount of municipal sewage, it can be used to buffer and dilute landfill leachates. Therefore, landfill leachates can be mixed in appropriate amounts with municipal sewage to adjust the C:N:P ratio and thus reduce the treatment load associated with W2E power plant leachates while providing a supplementary source of carbon for sewage plants [26,27]. Chen et al. [28] used the inverted A^2/O process to treat low-carbon municipal sewage. To address the poor denitrification capacity and suboptimal nitrogen/phosphorus removal efficiencies of this process, as well as the flaws of current regulation techniques, they conducted experiments to improve the productivity of the denitrification–regulation process: landfill leachate was added to municipal sewage (0.1%), the hydraulic retention time (HRT) of the primary sedimentation tank was reduced by 2/3, sludge concentration was raised to 4,500 mg/L, aerobic stage 1 was set as the denitrification transition stage, and the reflux ratio was increased. In this way, they succeeded in increasing carbon availability by more than 15%. To ensure that the biological treatment process of the sewage plant will operate normally when landfill leachates and municipal sewage are co-processed, Hang [29] pretreated the leachate to reduce its ammoniacal nitrogen content and then combined the leachate and municipal sewage in varying proportions. They found that 1‰ $FeCl_3$ and 20 g/L CaO increased the C/N and C/P values of the municipal sewage when it was mixed with pretreated leachate. In addition, aeration stripping of the coagulated leachate at room temperature (20°C–25°C) for 6 h further increased the C/N and C/P values of the mixed sewage. Shi et al. [30] employed inverted A^2/O to simultaneously perform carbon and nitrogen removal from landfill leachates and municipal sewage. Based on the results of orthogonal tests, they found that HRT is the most important factor in determining the efficiency of nitrogen and organic matter removal in mixed sewage.

Regarding Lu'an city in East China, a waste incineration power plant production for an average of 85 m^3/d use "precipitation pretreatment + UASB anaerobic reactor + adjust pool + two levels of A/O + ultrafiltration + two-stage network tube reverse osmosis membrane system" process, which are complex and direct operation cost (not including labor, equipment depreciation, maintenance) is more than 4.30 $\$/m^3$. In addition, another mixed urban sewage treatment plant in the same region has a design scale of 40,000 m^3/d in the first phase, and the actual operating capacity is only 0.8–12,000 m^3/d, which is treated by the process of "hydrolysis acidification + improved oxidation ditch + coagulation + precipitation + filtration". On account of the actual sewage treatment scale and inlet water quality are different from the design, the sewage treatment plant is in a long-term low-load operation state, and some treatment facilities fail to play a good role, resulting in the waste of equipment and energy consumption.

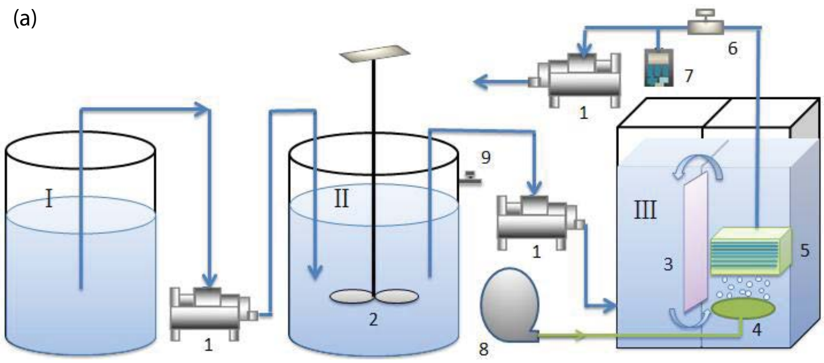
In this study, landfill leachate was combined with mixed municipal sewage according to local engineering practice, we combined HA pretreatment with membrane and SBR processes to improve the biodegradability of the subsequent treatment of wastewater and improve the COD removal effect. The efficiency of the HA-SBR-MBR process for the removal of organic matter, total nitrogen, total phosphorus, and other pollutants was monitored throughout our experiment. In addition, the combination of SBR and MBR could give play to a series of advantages of SBR process, such as small floor area, strong impact resistance, high oxygen transfer efficiency, simple process, high microbial activity, flexible operation, and easy to realize high automation [31]. At the same time, the efficient membrane interception would greatly improve the solid–liquid separation effect, strengthen the biological treatment effect of SBR, shorten the operating cycle of SBR, and obtain stable effluent. Moreover, membrane module in the late settlement stage to the suction filter of supernatant fluid, as the suspended particles in the supernatant fluid and the sludge content is small, which could effectively reduce the membrane fouling in separation process, the membrane component cleaning and replacement frequency, and to maintain the stability of the membrane filtration performance, thus to reduce the operation cost of the system and provide the reference for the local actual project reconstruction.

2. Materials and methods

2.1. Experimental equipment

An integrated MBR was used in this experiment for which the system flow and experimental equipment are shown in Figs. 1a and b. The MBR and hydrolytic tank were both 200 mm × 350 mm × 800 mm plexiglass cuboids. The MBR was roughly partitioned into two by a partitioning plate; the membrane modules were installed in one partition and a stirring device was installed in the other. An air compressor and microporous plate aeration was

(a)



(I) Raw water regulation basin; (II) Hydrolytic tank; (III) SBR tank; (1) Peristaltic pump; (2) Stirring device; (3) Partitioning plate; (4) Microporous aerator; (5) Membrane module; (6) Solenoid valve; (7) Differential pressure gauge; (8) Air compressor; (9) Overflow pipe.

(b)

Fig. 1. (a) System flow chart and (b) experimental apparatus.

used to supply oxygen to the reactor, and the aeration rate was controlled by a rotameter. During the aeration reaction stage, an upflow formed on one side of the reactor whereas a downflow formed on the other side. This homogenized the aeration of the reactor and enhanced the mass transfer effect. To slow the rise in transmembrane pressure due to membrane fouling, the system was operated with a constant current and intermittent drawing [32]; the duration of the draw and idle modes was 8 and 2 min, respectively. The experimental membrane modules were made from polyvinylidene fluoride (PVDF) hollow fiber membranes with a pore size of 0.1 μm. The surface area of each membrane module was 0.50 m^2, and there were three modules in total.

2.2. Experimental methods

The experiment was carried out in a sewage plant in Lu'an City, Anhui province, China, which the geographical coordinates were 116°31′59″ E and 31°49′32″ N. The sewage was taken from the collection well of the sewage plant, whereas the landfill leachate was taken from fresh leachates produced by a W2E power plant in Lu'an City, which the percolate rate was 0.17%. The water quality parameters of the mixed sewage are shown in Table 1.

Sludges from an operational sewage plant (anaerobic sludge from its hydrolytic tank and sludge residues from its secondary settlement pond) were used as seed sludge; anaerobic and aerobic acclimation of the sludge were carried out in parallel. The sludge concentrations of the hydrolytic tank and SBR tank were approximately 10 and 4 g/L, respectively. The process flow of the HA-SBR-MBR process was as follows: Regulation basin – Hydrolytic tank (12 h) – SBR tank (6 h). The fill time of the SBR was set to 10 min and aeration was initiated at the same time as the fill. The durations of the react, settle, draw, and idle modes were 4 h, 1 h, 50 min, and 10 min, respectively. The duration of each stage was controlled by time relays. The aeration rate, membrane flux, drainage ratio, and sludge age of this process were 0.3 m^3/h, 12 $L/(m^2\ h)$, 1:2, and 12 d, respectively. Moreover, the membrane modules were not physically or chemically cleaned during the operation of this system, and the changes in the membrane filtration resistance of the system were monitored throughout the experiment.

2.3. Analytical tools and methods

A Hach DRB200 digestor was used to quickly determine the chemical oxygen demand (COD), which was manufactured by Hach Water Quality Analysis Instrument Co., Ltd., (Shanghai). Total nitrogen was measured via potassium persulfate oxidation–UV spectrophotometry. Ammoniacal nitrogen was measured using the salicylic acid method. Total phosphorus was determined via the alkaline potassium persulfate digestion–ascorbic acid method. Five-day biochemical oxygen demand (BOD_5) was measured using a BI microbial electrode BOD sensor. Turbidity was measured using a WGZ-1 digital turbidity meter. The value of mixed liquor suspended solids was determined using the loss-on-drying method. pH was measured using a Delta 320 pH meter. Dissolved oxygen (DO) was determined using a Hach HQ30d portable dissolved oxygen meter.

3. Results

3.1. COD removal efficiency

Fig. 2 illustrates the efficiency of COD removal from the system's effluent and the reactor's supernatant when the HA-SBR-MBR system was in continuous operation. It can be seen that the COD concentrations of the inflow regulation basin and hydrolytic tank varied between 202–316 and 150–252 mg/L, respectively, when the system was in continuous operation. The COD of the system's effluent was 8–19 mg/L, which corresponds to a total COD removal rate of 91.5%–97.5% (95.1% on average). The COD concentration of the supernatant was 9–29 mg/L, which corresponds to a total COD removal rate of 87.6%–94.4% in the bioreactor (91.3% on average). By comparing the COD removal rates of the membrane effluent and supernatant, it becomes apparent that the organic pollutants were mainly removed by activated sludge. The membrane's contribution to the COD removal rate was 1.3%–7.6% (3.7% on average). This also shows that the membrane intercepts organic macromolecules in the bioreactor and thus increases the COD removal efficiency of the system. In this way, the membrane plays an important role in maintaining the stability of the system.

3.2. Efficiency of ammoniacal nitrogen and total nitrogen removal

The system's efficiencies for the removal of ammoniacal nitrogen and total nitrogen are shown in Fig. 3. The total ammonia nitrogen removal rate of the system was 91.6%–100.0% (average 97.5%), while the removal rate of ammonia nitrogen was 0–4.9% (average 1.7%). This indicates that the membrane has little interception of ammonia nitrogen, and the removal of ammonia nitrogen is mainly achieved by biological nitrification and assimilation. On the one hand, as the aeration lasts for 4 h and the aeration strength remains unchanged, the organic load of the system

Table 1
Water quality of the sewage and landfill leachate mixture

Parameter	COD (mg/L)	BOD_5 (mg/L)	TN (mg/L)	pH	Turbidity (NTU)	NH_3–N (mg/L)	TP (mg/L)	Temperature (°C)
Wastewater	153.0–220.1	66.6–133.3	9.9–20.8	7.12–8.06	172–258	6.26–15.9	1.89–2.43	23–28
Leachate	39,500–62,000	18,200–38,500	1,720–3,050	5.12–6.01	/	1,250–2,200	12.4–26.5	23–28
Mixture	202–296	89.0–193.0	14.6–24.2	6.56–7.10	172–258	9.5–16.4	2.02–2.62	23–28

in the later aeration period is low, which is conducive to the growth of autotrophic nitrifying bacteria [33]. On the other hand, the efficient membrane interception prevents the loss of nitrifying bacteria with a long generation time, the system nitrification performance is good [34], and the ammonia nitrogen value of both supernatant and membrane outlet is kept at a low level, or even not detected. What is more, the total nitrogen removal rate of the system was 52.7%–72.2% (61.9% on average), while the total nitrogen removal rate of the membrane itself was 0–5.3% (0.9% on average). This indicates that the membrane itself does not enhance the total nitrogen removal efficiency.

3.3. TP removal efficiency

The total phosphorus (TP) removal efficiency of the system is shown in Fig. 4. After the system becomes aerobically and anaerobically acclimated, the phosphorus-accumulating organisms in the reactor will have adapted to the alternatingly anaerobic and aerobic environment, thus resulting in excellent TP removal efficiencies [35,36]. The total phosphorus concentration of the regulation basin was 2.08–2.62 mg/L, whereas the total phosphorus concentration of the membrane effluent was 0.08–0.34 mg/L (0.21 mg/L on average). Hence, the total phosphorus removal rate was 85.1%–94.7% (91.1% on average).

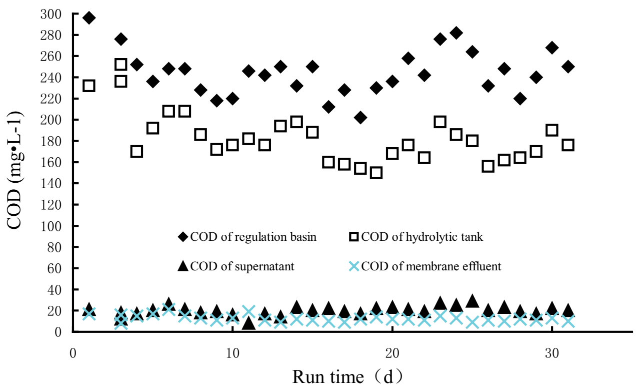


Fig. 2. COD removal efficiency.

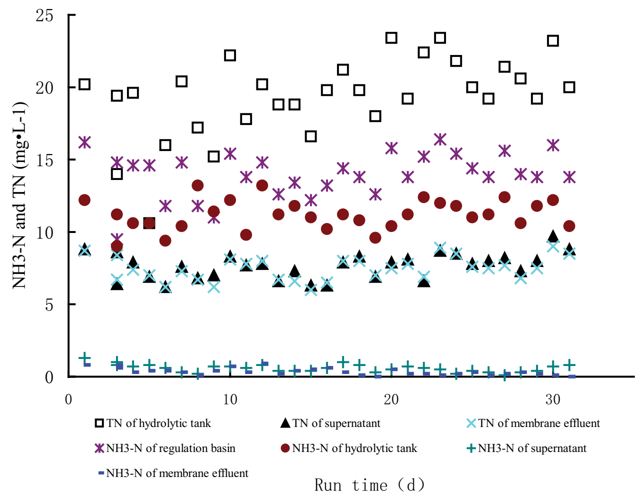


Fig. 3. Removal efficiency for ammonia and total nitrogen.

3.4. Turbidity removal efficiency

According to Fig. 5, the turbidity of the bioreactor's supernatant was not stable during the test; it ranged from 24 to 58 NTU. The turbidity removal rate of the supernatant ranged from 77.1% to 87.2% (81.5% on average). The turbidity of the system's effluent was stable and ranged from 1.0 to 2.8 NTU. The total turbidity removal rate was 99.0%–99.5% (99.2% on average). The turbidity removal rate of the membrane itself was 12.1%–22.1% (17.7% on average). This indicates that the membrane was effective in intercepting suspended solids and biosludges in the reactor, which improved and stabilized the effluent quality of the system.

3.5. Membrane fouling

Usually, membrane fouling is characterized by fouling resistance. Membrane filtration resistance is proportional to trans-membrane pressure and inversely proportional to membrane flux, as the following:

$$\text{Rt} = \frac{\Delta P}{(\mu J)} \quad (1)$$

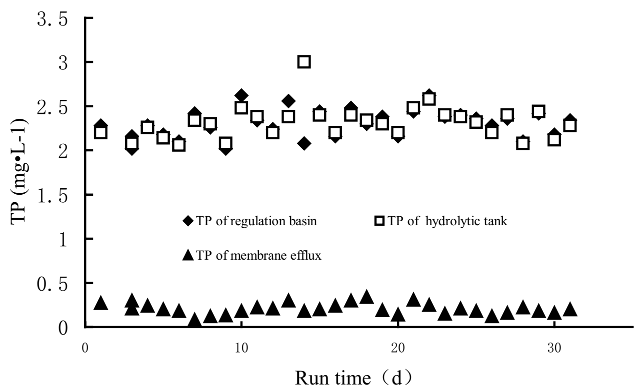


Fig. 4. Total phosphorus removal efficiency.

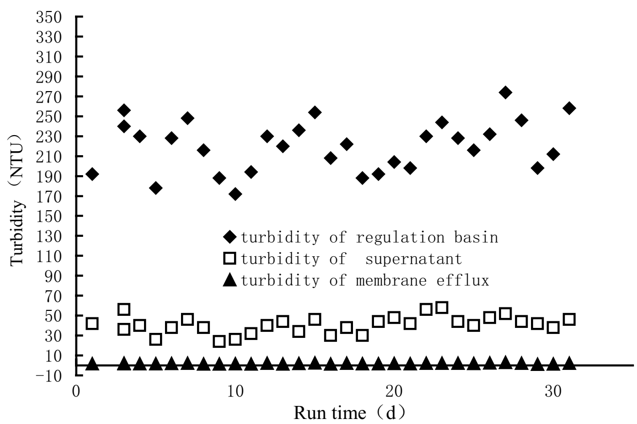


Fig. 5. Turbidity removal efficiency.

where J is the membrane flux, $m^3/(m^2\ s)$; ΔP is the pressure difference on both sides of the membrane, Pa; Rt is the total resistance of membrane filtration, m^{-1}; μ is the viscosity of the transmission fluid, Pa·s.

This experiment was conducted continuously for 31 s with the membrane no cleaned in any way during this period, Fig. 6 illustrates the total membrane filtration resistance vs. operating time, it can be seen that the operating pressure of the membrane progressively increased from 7.07 kPa to nearly 15.21 kPa and the total membrane filtration resistance had increased from 2.34×10^{12} to $5.03 \times 10^{12}\ m^{-1}$. The experimental results also show that membrane fouling progressed quite slowly in this system. This can be attributed to the use of hollow fiber membranes to filter the supernatant during the settlement stage of the SBR process, as the content of suspended matter and sludge particles in the supernatant is small, which reduced the adsorption and deposition of suspended substances and sludge particles on the membrane surface during the supernatant drawing process. This effectively reduced membrane fouling during the separation process and thus maintained the stability of membrane's filtration performance. In addition, membrane separation improved the solid–liquid separation efficiency of the SBR process (which can be low due to sludge settling problems), thus improving effluent quality.

4. Discussion and conclusions

- Literature [26] adopted the inverted A^2/O process to carry out the production test of treating leachate and municipal sewage. When the mixed proportion of leachate was 0.14%, the values of COD, NH_3–N and TN of mixed sewage are in the range of 82–387 mg/L, 21.8–57.9 mg/L, 22.0–58.2 mg/L, the water temperature was 13°C–27°C, sludge age of 20 d, HRT for 9 h, DO for 2 mg/L, reflux ratio 80%, and under the condition of the reflux ratio of 200%, the removal rates of COD, NH_3–N and TN were 74.7%–87.8%, 87.2%–98.6% and 51.8%–67.4%, respectively. The removal efficiency of nitrogen and carbon was good, and the effluent concentration could meet class A of discharge standard of pollutants for municipal wastewater treatment plant (GB18918-2002) stably. However, the above study did not analyze the removal of TP, as the landfill leachate water changed greatly, and the instantaneous mixing of leachate had a large impact load on the sewage treatment plant, which had not been solved. Literature [27] analyzed the adverse effects of landfill leachate water volume change, the unstable entry time of leachate, and the imbalance of nutrient elements in leachate on the operation process of wastewater treatment plant. In order to reduce the adverse effects of leachate on urban sewage treatment plants, the paper put forward some countermeasures, such as studying the maximum mixing ratio of leachate, setting up regulating tank, optimizing operation process parameters, adding biological filler to aerobic tank as the carrier of enriching microorganism and nitrifying bacteria, strengthening equipment maintenance and management of leachate access point.

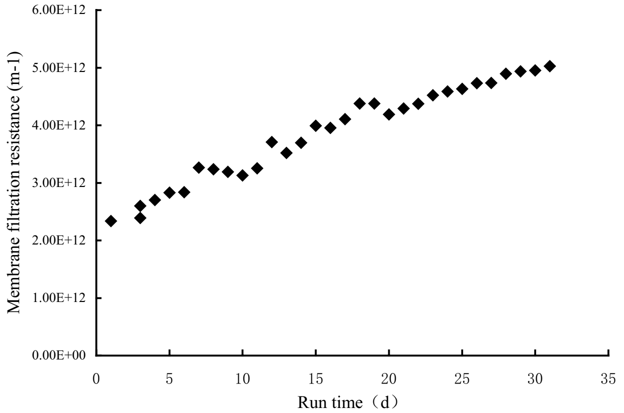


Fig. 6. Changes in membrane filtration resistance.

In this study, HA-SBR-MBR was used to treat the mixed municipal wastewater and landfill leachate. The leachate was fresh, which is produced in the same day in the municipal solid-waste incineration plant, and its composition was relatively stable, the impact of the leachate on the sewage treatment can be greatly reduced, and thus the adverse effect on the biological treatment unit process can be reduced. In addition, through the alternate anaerobic/aerobic operation, a suitable growth environment was created for the phosphorus accumulating bacteria. The total phosphorus concentration of the effluent from the system membrane was 0.08–0.34 mg/L, and the total phosphorus removal effect was better. At the same time, the nitrate bacteria and nitrite with long generation period were enriched in the system by the membrane interception, which improved the nitrification performance of the system, and the removal effect of NH_3–N and TN was good.

- Yuan et al. [37] investigated the effects of landfill leachate on nutrient removal from the Brady road landfill in Winnipeg and municipal wastewater by treating the landfill site without pretreatment at different mixing ratios. The COD, BOD_5, NH_3–N, TN, TP and pH of landfill leachate were within the range of 2,366 ± 526 mg/L, 248 ± 20 mg/L, 699 ± 112 mg/L, 772 ± 65 mg/L, 5.9 ± 1.7 mg/L, 7.2 ± 0.4, respectively. The COD, BOD_5, NH_3–N, TN, TP and pH of the sewage plant are, respectively, within the range of 363 ± 158 mg/L, 198 ± 35 mg/L, 41.1 ± 9.2 mg/L, 50 ± 8.6 mg/L, 5.9 ± 1.7 mg/L, 7.4 ± 0.0. The results showed that when the mixing ratio was 2.5%, the leachate was not pretreated, and the SBR process was used to treat the landfill leachate and municipal sewage together with better results. The COD removal rate was stable at 81%–87%, and the effluent NH_3–N was 34.9 ± 4.4 mg/L, and the TP removal rate was close to 100%. Besides, high ammonia-nitrogen concentration had no negative impact on nitrification, the system can adapt to the environment and improve the nitrification capacity, and may not require pretreatment of leachate to reduce ammonia content, so it is more economically feasible.

In the above study, the concentration of COD, NH_3–N and TN in landfill leachate was much lower than that in this study, so the dosage ratio was much higher. However, its NH_3–N could not achieve a good removal effect, and the effluent water quality of this study was generally superior to the results in the literature [36].

- Literature [38] conducted a demonstration study on collaborative treatment optimization, regulation and long-term operation of domestic sewage and garbage leachate in small and medium-sized urban sewage treatment plants in the Three Gorges Reservoir area. Small, pilot and field studies show that the appropriate reflux ratio, dissolved oxygen, sludge concentration and sludge age of A^2/O process can be controlled through the regulation of the inflow of landfill leachate. At the same time, according to different seasons, a long-term operation plan has been formed. For sewage treatment plants with the proportion of waste leachate sink below the access load (about 1:35), COD, SS, NH3–N, TN and TP can stably meet class B of discharge standard of pollutants for municipal wastewater treatment plant (GB18918-2002).

In the literature [28], a large sewage treatment plant in Chongqing adopted an inverted A^2/O process to treat low-carbon source urban sewage. In view of the lack of denitrification capacity, poor effect of denitrification and phosphorus removal and the defects of control technology in operation, a productive experimental study was conducted to strengthen the comprehensive control technology of nitrogen removal. In the season of room temperature and high temperature in 2008, landfill leachate was added (with an allocation rate of 0.1%), and the removal rate of NH_3–N in the system was about 90%, so the NH_3–N concentration in the effluent was basically about 2.5 mg/L. Additionally, the average removal rate of TN was about 54%, and the effluent TN was about 17 mg/L, achieving a good denitrification effect. After intensive comprehensive control of denitrification in the low temperature season, the effluent NH_3–N concentration was about 3 mg/L, which was somewhat higher than that in the normal high temperature period, so the effluent TN concentration was maintained at about 15.5 mg/L, which was close to the class A standard.

In this study, the leachate allocation rate was 0.17%, and the average removal rates of COD, TN, NH_3–N, TP and turbidity of the system were 95.1%, 61.9%, 97.5%, 91.1% and 99.2%, respectively. The effluent could meet the discharge standard of pollutants for municipal wastewater treatment plant (GB18918-2002) level A. The membrane itself has a good retention effect on fine suspended matter and biological sludge in the mixture, which of the average removal rate of COD and turbidity were 3.7% and 17.7%, respectively, and the enhanced removal effect of turbidity was significant. In addition, the interception of nitrobacteria and nitrite bacteria with long generation cycle greatly improved the nitrification performance of the system, which played an important role in the stability of effluent water quality.

- According to the characteristics of SBR with aeration – sedimentation – intermittent operation, hollow fiber microfiltration membrane was used to filter the supernatant at the settling stage. Due to the small content of suspended matter and sludge particles in the superfluid, the stability of membrane filtration performance was well maintained while ensuring the removal effect of pollutants, the development speed of membrane pollution in the separation process was effectively reduced, and the frequency of membrane module cleaning and replacement was reduced, which provided a foundation for the continuous and stable operation of the system. This test has a simple technological process and a stable effect of nitrogen and phosphorus removal in the system, which not only reduces the burden of leachate treatment in waste incineration plant but also adds carbon source for the mixed sewage plant running under low load. Therefore, it shows that the combined treatment of leachate and municipal sewage is economically and technically feasible, which can provide reference for the mixed sewage plant with low load operation which is limited by the site.
- At present, this study is still in the experimental exploration stage, and the optimization control of operating process parameters is being studied. In the later stage, we will carry out quantitative analysis on organic species and heavy metals in the reactor mixture, and the membrane fouling behavior will be accurately predicted by means of three-dimensional fluorescence spectrum, infrared spectrum, energy spectrum analysis and other technical means, which will be to optimize the operation mode of membrane module, cleaning method, and provides the theory basis for the effective control of membrane fouling.

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