2013 2nd International Conference on Environment, Energy and Biotechnology
IPCBEE vol.51 (2013) © (2013) IACSIT Press, Singapore
DOI: 10.7763/IPCBEE. 2013. V51. 1

Advanced Nitrogen Removal from Landfill Leachate without External Carbon Addition Using a Modified SBR Process

Wang Kai [1], Wang Shuying [1+], Miao Lei [1], Li Zhongming [1]

1 Engineering Research Center of Beijing, Beijing University of Technology, Beijing, China

Abstract. In order to achieve advanced nitrogen removal from landfill leachate without external carbon addition, a novel process applying modified sequencing batch reactor (SBR) was proposed for the treatment of real landfill leachate. This process was firstly operated under anaerobic mode and then nitritation was performed under alternate anoxic/aerobic mode. When nitritation was finished, advanced nitrogen removal was realized at the expense of endogenous denitritation. The accurate indication of reaction by real-time control saved the operation cost potentially together with the usage of internal carbon source. More significantly, low sludge production under long-term endogenous metabolism simplified the wasted sludge disposal.

Keywords: landfill leachate, SBR; nitrogen removal; real-time control

1. Introduction

As a typical wastewater containing lots of organics and ammonia nitrogen, landfill leachate without treatment has polluted environment seriously [1]. Now the treatment of landfill leachate contains physical methods [2], chemical methods [3] and biological methods [4]. In terms of cost-effective and reusable capability and secondary pollution to environment, biological methods predominate in contrast with other treating methods [5].

Now, most of researchers have shown that the ammonium of leachate could be removed effectively using biological process and total nitrogen (TN) could be removed via denitritation with external carbon addition [6], [7]. However, traditional denitritation not only wastes the carbon source of the leachate, but also increases the treatment cost.

For purposes of advanced treatment, some novel technologies are of great importance. In this study, a novel process applying modified sequencing batch reactor (SBR) was proposed for advanced nitrogen removal by making full use of the carbon source of the leachate. This process has achieved good TN removal efficiency under real-time process control. Furthermore, low sludge production was achieved under long-term endogenous metabolism.

2. Materials and Methods

2.1. Experimental set-up and seed sludge

The working volume of SBR made of polymethyl methacrylate was 10L with an internal diameter of 20cm and a height of 60cm. The exchange volumetric rate of SBR was 15%. The system was maintained at 25±1℃ and DO in the nitritation was maintained at 0.5-1mg/L. The aerobic activated sludge from the nitritation reactor treating mature leachate was used as the inoculums of the SBR and MLSS was 4500 mg/L.

The experiment consisted of two stages: start-up stage (0th day-41th day) and stabilization stage (42th day-113th day).

+ Wang Kai. Tel.: + 86 10 67392627; fax: +86 10 67392627.
E-mail address: wsy@bjut.edu.cn

2.2. Raw wastewater and operational scheme

The main characteristics of the wastewater were as follows.COD 3200mg/L-3800 mg/L，NH_4^+-N 800mg N/L-900mg/L，alkalinity（$CaCO_3$）8000 mg/L-11000 mg/L，pH=7.8-8.2

This system was firstly operated under 0.5h anaerobic mode and then nitritation and denitritation were performed under alternate anoxic/aerobic mode. The alternate time was half an hour. When nitritation was finished, endogenous denitritation was performed by continuous stirring until the end of reaction. The total time of one cycle was maintained at 33h under the condition of that nitritation was over. If advanced nitrogen removal was not achieved during 33h at the start-up stage, the external carbon source was added until all of nitrogen was removed.

2.3. Analytic Methods

DO, pH, ORP and temperature were monitored by using pH/Oxi 340i analyzer (WTW Company, Germany).Ammonium, NO_3^--N, NO_2^--N and COD were measured according to the standard methods (APHA, 1995).TN was analyzed by using TN/TOC analyzer (MultiN/C3000, AnaltikjenaAG, Germany).

3. Results and Discussion

3.1. Advanced nitrogen removal from landfill leachate in modified SBR

The results of treating landfill leachate in modified SBR were shown in Figure 1. During the 110 days experiment, the influent and effluent COD were 3200mg/L~3800 mg/L and 450mg/L~550 mg/L, respectively, and the COD removal efficiency kept at about 85%. The aerobic activated sludge from the nitritation reactor treating mature leachate was used as the inoculums of the SBR. The inoculums contained little denitrifying bacteria, resulted in a stable nitritation. However, denitritation could not be finished in one cycle during the period of previous 40 days operation. The initial NH_4^+-N concentration of the system was about 125 mg N/L, and the NO_2^--N concentration was 80 mg N/L at the end of one cycle with TN removal efficiency 36%. 26% TN was removed under the alternate anoxic/aerobic mode and 10% TN was removed via endogenous denitritation. The remaining TN was removed by denitritation with external carbon addition. The external carbon source resulted in the growth of denitrifying bacteria, which also enhanced nitrogen removal ability. From day 41, above 95% TN was removed in one cycle and about 50% TN was removed via endogenous denitritation. During the following 72 days, the effluent TIN and TN stayed below 10 mg N/L and 40 mg N/L, respectively, which suggested that advanced nitrogen removal was achieved with the carbon source of the leachate.

The variation of MLSS concentration in the system was shown in the Figure 2. During the previous 50 days operation, MLSS and MLVSS both increased until the 50th day reached the maximum of 8156mg/Land 5853mg/L, respectively. Since the denitrifying ability was enhanced, the increase of MLSS resulted from the growth of denitrifying bacteria.

From day 51, the MLSS concentration kept at 8100mg/L~8300mg/L, which may result from two reasons. Firstly, under the special operation scheme, most of organics were used to denitrify, led to the slow growth of denitrifying bacteria. Under the 0.5h anaerobic mode, many organics were absorbed by denitrifying bacteria and transformed into the inner carbon source (mainly PHA) which was used for the following endogenous denitritation.

3.2. All parameters variations of modified SBR

The COD and nitrogen variations in one cycle were shown in Figure 3. As shown in Figure 3, one cycle included two stages. The first stage was alternate anoxic/aerobic stage and the second stage was anoxic stir stage. The first stage lasted 7 hours to remove organics and ammonia nitrogen. Besides, part of nitrogen was removed via simultaneous nitritation and denitritation (SND) and denitritation using the indigenous carbon source of leachate during the first stage. The second stage lasted 25 hours to denitrify using the storage of carbon source (such as PHA).

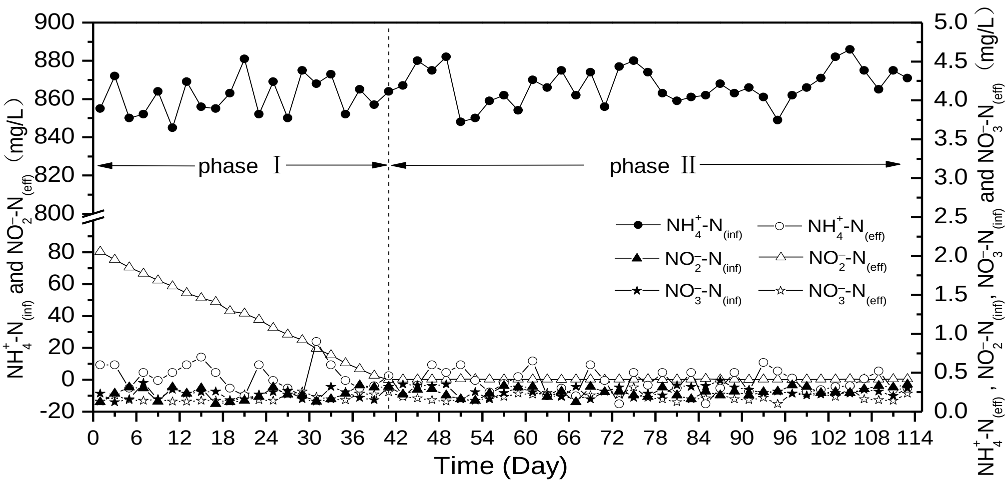

Fig. 1 The transformation of nitrogen in the phase of initiate and stable

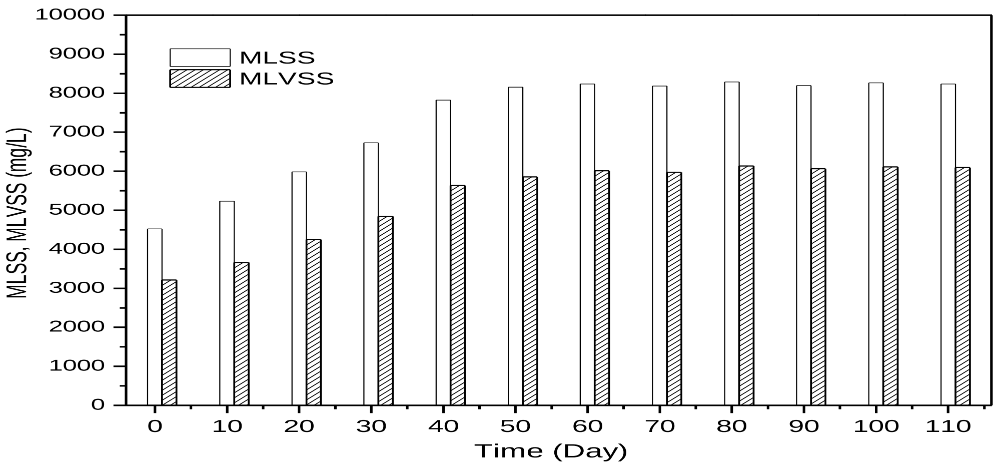

Fig. 2 variation of MLSS and MLVSS in the phase of initiate and stable

During the first stage, TN decreased for two reasons. On one hand, since the ammonia nitrogen and COD had been both oxidized under aerobic mode, the nitrite produced was removed via denitritation using the indigenous carbon source of leachate under anoxic mode. As shown in Figure 6, nitrite, TN and COD all reduced under anoxic mode, which suggested COD in the leachate was used by denitrifying bacteria to denitrify. On the other hand, the DO was controlled at 0.5mg/L, which led to TN removal via SND. When the first stage was over, the nitrite and TN concentrations reached 65 mg N/L and 75 mg N/L, respectively. Compared with 140 mg/L of influent, TN concentration reduced almost 50%. So it can be seen that through the alternate anoxic/aerobic mode, not only ammonia nitrogen was oxidized, but also about 50% TN was removed via denitritation and SND.

During the second stage, nitrogen was advanced removal at the expense of endogenous denitritation. As shown in Figure 3, the nitrite concentration decreased during anoxic stir stage. However, the COD concentration of the system kept stable without adding any external carbon source, which suggested the denitrifying bacteria used the inner carbon source to remove nitrogen. After anoxic stir stage of 25 h, about 70 mg N/L TN was removed via endogenous denitritation. That showed the sludge had perfect capability of storing carbon source, which may resulted from three reasons. Firstly, the enough organics in the influent and 0.5 hour anaerobic mode made the sludge store enough inner carbon sources. That was the key to the endogenous denitritation. Secondly, the low DO concentration (0.5 mg/L) during nitritation inhibited the activity of aerobic bacteria. So the consumption of inner carbon source was reduced during the aeration. Thirdly, the high MLSS concentration (8000mg/L) could provide more inner carbon source, which enhanced the capability of endogenous denitritation.

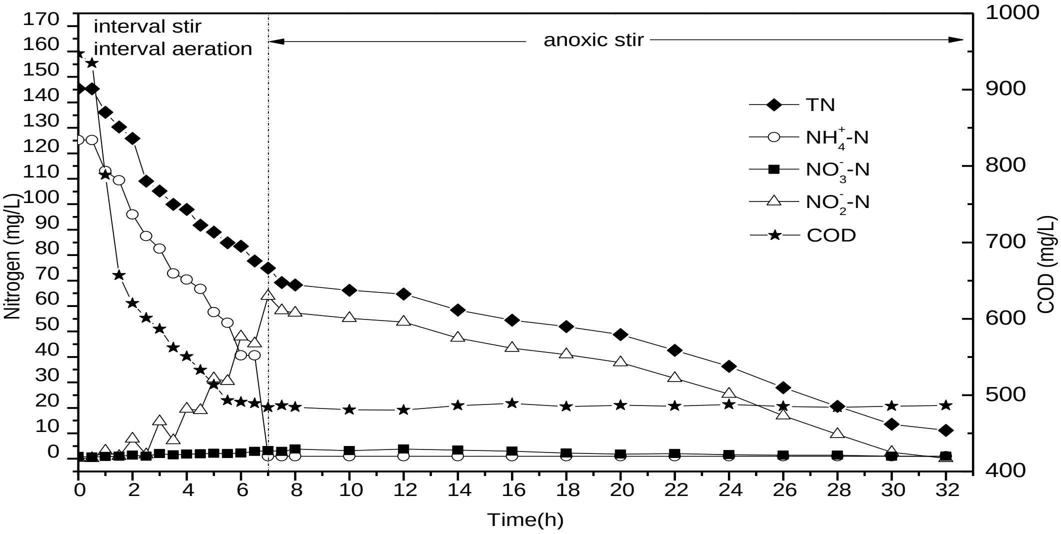

Fig. 3 Typical variations of nitrogen during processes of SBR cycle

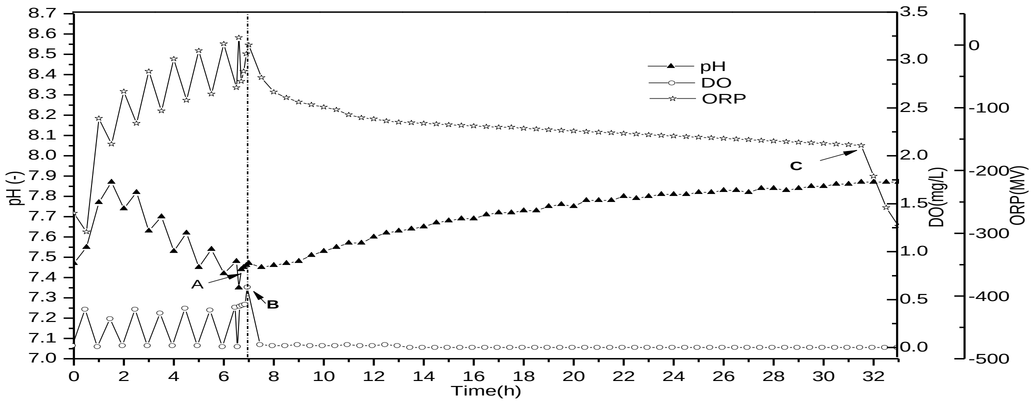

Fig. 4 Variations of pH, DO and ORP of SBR cycle

The variations of pH, DO and ORP of SBR cycle were shown in Figure 4. During 6.5h-7h, one significant point (point A) called the "ammonia valley" in the pH profile was easily discerned. At the same time, there was also a characteristics point (point B) in the DO profile. After point A and B, the ammonia was oxidized completely, so DO increased largely. However alkalinity was no more consumed by nitrifying bacteria, resulting in pH increased under the effect of carbon dioxide stripping. The point A and B could accurately indicate the terminal of nitritation. Aeration should be stopped in time no sooner than the appearance of point A, which could save the energy consumption and reduce the influence of aeration to inner carbon source. During 31.5h-32h, one significant point (point C), which was called "nitrate knee", was discerned in the ORP profile. After point C, the NOx- was removed completely, so ORP decreased rapidly. That indicated the denitritation was over when point C appeared. So it can be seen that, through the real-time monitoring of pH, DO and ORP, the terminal points of nitritation and denitritation could be judged accurately and the system efficiency could be improved.

4. Conlcusion

This study applied modified SBR to treat real landfill leachate. The following conclusions could be drawn:

The operation mode of SBR was modified by adding the stir stage before and after nitritation stage. That could improve the nitrogen removal efficiency by full usage of the indigenous carbon source. During one cycle, the terminal points of nitritation and denitritation could be judged accurately via the real-time monitoring of pH, DO and ORP, and the system efficiency could be improved.

After the acclimatization of 42 days, the advanced nitrogen removal had been realized without adding external carbon source. The effluent TN concentration was below 40mg/L, and the removal efficiency reached above 95%. During 160 days operation period, the MLSS concentration stayed at about 8000mg/L. The low sludge production under long-term endogenous metabolism simplified the wasted sludge disposal.

5. Reference

[1] A. C. Silva, M. Dezotti, G. L. Sant'Anna Jr. Treatment and detoxication of a sanitary landfill leachate. Chemosphere. 2004, **55**(2):207-214

[2] A. Zouboulis, W. Jun, A. Katsoyiannis. Removal of humic acids by flotation, Colloids Surf. A: Physicochem. Eng. Aspects. 2003, **231** (1-3):181-193

[3] Y.W. Kang, and K. Y. Hwang. Effects of reaction conditions on the oxidation efficiency in the Fenton process, Water Res. 2000, **34** (10):2786-2790

[4] A. Gálvez, L. Giusti, M. Zamorano, A.F. Ramos-Ridao. Stability and efficiency of biofilms for landfill leachate treatment. Bioresour. Technology. 2009,**100** (20):4895-4898

[5] E. Klimiuk, anf D. Kulikowska. Organics removal from landfill leachate and activated sludge production in SBR reactors. Waste Management. **26** (10):1140-1147

[6] H. Sun, Q. Yang, Y. Peng, X. Shi, S. Wang, S. Zhang. Nitrite Accumulation during the denitrification process in SBR for the Treatment of pre-treated Landfill Leachate. *Chinese Journal Of Chemical Engineering*. 2009, **17** (6):1027-1031

[7] L. Wu, C. Peng, S. Zhang, Y. Peng. Nitrogen removal via nitrite from municipal landfill Leachate. *Journal of Environmental Sciences*. 2009, **21** (11):1480-1485