Study on treatment of concentrated solution by landfill leachate membrane filtration

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Abstract. With the rapid development of economy and science and technology level unceasing enhancement, our country's industrialization development is rapid, the resulting increase in the number of garbage also gradually, landfill is the main way of garbage disposal in China at present stage, the landfill method can produce lots of rubbish leachate disposal of garbage, it is a kind of complicated composition of high concentration organic wastewater. In recent years, the treatment of landfill leachate with new membrane separation technology represented by reverse osmosis and nanofiltration has been widely used in Europe and America and other developed countries and regions. The present research on the treatment of concentrated solution by landfill leachate membrane filtration is reviewed.

Keywords. Reverse osmosis; Membrane separation; Leachate

1. Pollution of domestic garbage leachate is present

At present, China's urban household refuse has not been effectively classified and recycled on a large scale, resulting in the complexity of the garbage components in centralized treatment, which requires proper treatment of the contaminated components in the garbage field. For the landfill, the treatment of leachate up to the standard is of vital importance. If the treatment of landfill leachate cannot be effectively digested in the factory, it will be discharged into the external environment carelessly, and the leachate with complex components will enter the soil, surface or underground water body, which will deteriorate the water quality and soil quality and cause serious environmental pollution[1]. If the soil and groundwater are contaminated by leachate, it will be persistent and difficult to recover in a short time. When the construction quality of the anti-seepage membrane project in the landfill is not up to the standard or reasonable measures of anti-seepage and separation of rain and sewage are not taken, the leachate will flow out and pollute the land. Therefore, the quality of the corresponding soil will decrease, which will seriously cause the loss of soil use function [2].

In the actual design, based on the measured data of leachate characteristics of similar landfill sites around China, the composition characteristics of leachate in domestic landfill sites were summarized by referring to relevant data, as shown in the table below.
Table 1. Water quality index of landfill leachate

| Indicators         | Composition | Scope       | Typical | Indicators         | Composition | Scope | Typical |
|--------------------|-------------|-------------|---------|--------------------|-------------|-------|---------|
| BOD (mg/l)         | 1660-24300  | 9000        |         | Nitrate            | 6-85        |       | 30      |
| TOC (mg/l)         | 3095-22230  | 7500        |         | Total phosphorus   | 7-44        |       | 25      |
| COD (mg/l)         | 5020-43300  | 15000       |         | Alkalinity         | 5000-11000  |       | 3500    |
| SS (mg/l)          | 6740-48400  | 1100        |         | PH                 | 6.51-8.25   |       | 6.89    |
| Organic nitrogen   | 46-816      | 250         |         | Total hardness     | 300-5400    |       | 2100    |
| Ammonia nitrogen   | 941-2850    | 1200        |         |                    |             |       |         |

2. Process flow

The leachate from the regulating pond of the landfill is converted into biochemical activated sludge through the lifting system into biochemical unit.

Under the power of ultrafiltration feed pump, activated sludge of biochemical unit flows through the first stage denitrification, first stage denitrification, second stage denitrification and second stage denitrification system successively and returns to the first stage denitrification system to form an internal circulation loop. In the denitrification system, a liquid agitator is set up to screw the activated sludge [3]. The nitrification system provides dissolved oxygen for activated sludge by a combination of air supply composed of blower, jet pump and aerator.

The membrane processing unit consists of three parts: external ultrafiltration, nanofiltration and reduction system. An external ultrafiltration system separated the nitrated activated sludge from solid to liquid, and the ultrafiltration concentrate was returned to the denitrification process as residual sludge. Ultrafiltration effluent buffer through the water tank into the nanofiltration system for further treatment [4]. The nanofiltration liquid enters the outlet water storage tank directly, and the concentrated liquid is separated through the reduction system. The humic acid and the reconcentrated liquid of the reduction system are transported and disposed of [5]. The cleaning liquid of the reduction system is filtered by activated carbon and then mixed into the water for storage and filtration.

Figure 1. Flow chart of leachate treatment process
As the final disposal site of hazardous waste, safe landfill realizes the principle of centralized disposal of hazardous waste, maximally isolates hazardous waste from the biosphere, effectively controls the migration of hazardous waste, and is an important measure to reduce environmental risks of hazardous waste and prevent and control environmental pollution[6]. In the operation stage of the safe landfill, rainwater infiltration from the gap of the covering film will produce leachate, which will discharge the pollutants from the hazardous waste out of the landfill and create the hidden danger of secondary pollution. Therefore, how to realize the reasonable and effective disposal of leachate in the safe landfill is an important link to control the diffusion of hazardous waste pollutants.

According to the nature of landfill waste, the main pollution components of leachate produced by the safe landfill are organic pollutants, inorganic pollutants (such as heavy metal pollutants, nonmetallic pollutants), ammonia nitrogen, etc. The leachate produced by hazardous waste landfill site is lower than that of domestic waste landfill site in COD and ammonia nitrogen content. Generally, inorganic pollutants such as heavy metals, sulfides and fluoride can be removed by chemical precipitation[7]. Ammonia nitrogen can be removed by nitrification or denitrification. Organic pollutants are difficult to be degraded due to their complex species and certain biotoxicity. Biochemical method is considered to be the most economical and effective method to remove organic pollutants from leachate. However, due to the presence of toxic substances in leachate that hinder the growth and reproduction of microorganisms, it is necessary to conduct pre-treatment before entering biochemical reaction[8].

Centralized sanitary landfill is the main way of urban solid waste treatment in China at the present stage. Leachate is a highly polluting emission generated by landfill during the degradation process. Its water quality is complex, which has a serious impact on the whole production and living environment. In view of the harm of landfill leachate to human beings and social environment, in order to prevent the secondary pollution caused by the landfill of domestic garbage, each country has formulated the landfill leachate discharge standard according to the national conditions, which is used to solve the leachate discharge problem [9]. In 2008, the state promulgated the pollution control standards for domestic garbage landfill (gbi 6889-2008), which put forward higher requirements on the treatment and discharge of leachate from landfill.

3. Ultrafiltration membrane pretreatment can delay reverse osmosis membrane pollution
Ultrafiltration membrane is generally used as reverse osmosis pretreatment process in traditional processes. This method has some disadvantages, mainly manifested as fewer absolute barriers. The performance of ultrafiltration and microfiltration membrane is relatively higher at the present stage, and the water quality produced by ultrafiltration membrane has been improved to a greater extent compared with the water quality produced by traditional processes. Currently, hollow fiber membrane is generally used in most cases, and its characteristics are mainly reflected in two aspects: on the one hand, the fiber fiber has a higher frequency, shorter time and higher degree of automation in the process of washing and backwashing. In this case, the system can maintain a stable permeable water flux in the short term offline. Hollow fiber membranes, on the other hand, can operate at lower cross-flow rates. The main advantage of the present ultrafiltration pretreatment method lies in membrane technology[10]. The existence of membrane barrier between water supply and water permeability makes colloids and bacteria drop several log values. In the process of waste water treatment, the original lime clarification and media filtration have been replaced by the new reversible hollow fiber membrane pretreatment, and this operation mode has a better effect on sewage treatment[11]. After observation and research, the treated inlet water quality has been controlled within 0.2nut.

4. Calculation of leachate production

4.1. Calculation formula
In order to implement the harmless management of the landfill site, it is necessary to construct the leachate water volume regulation and treatment facilities. In order to determine the treatment capacity
of such water treatment facilities and the capacity of the regulating device, it is necessary to make corresponding prediction and calculation on the leachate production in the landfill process. There are two main calculation methods of leachate: water balance method and empirical formula method.

1. Water balance method

   Landfill is the main body. According to the balance of water flow in and out of landfill, the calculation formula of leachate production is as follows:

   \[
   \text{Inflow} = \text{Outflow} \\
   I \cdot A/1000 + S_1 + G + W = E \cdot A/1000 + S_2 + Q
   \]

   Where
   - \(I\) = atmospheric rainfall (mm)
   - \(A\) = the catchment area of the landfill (m²)
   - \(E\) = the amount of water on the surface of soil or garbage due to sun exposure, wind evaporation and transpiration through plants
   - \(S_1\) = the amount of water entering the landfill from off-site transport (m²)
   - \(S_2\) = the rainwater that falls into the landfill forms surface runoff and is discharged off the site through the rainwater discharge facility (m²)
   - \(G\) = the amount of underground water infiltration into the landfill (m²)
   - \(Q\) = leachate production (m²)
   - \(W\) = with garbage \(\Delta t\) time and the amount of water in soil into landfill (m²)

2. Empirical formula method:

   The empirical formula is as follows:

   \[
   Q = C \cdot I \cdot A/1000/365 + W
   \]

   Where
   - \(Q\) = average daily leachate production (m³/d)
   - \(C\) = seepage coefficient
   - \(I\) = average annual rainfall (mm/a)
   - \(A\) = the catchment area of the landfill
   - \(W\) = daily amount of leachate produced

### 4.2. Production calculation of leucate is a common choice

Garbage leachate discharge of water consumption balance method is difficult to water of not a relatively accurate assessment, deviation tend to be more big, the proposed practical use, draw lessons from a view of the surrounding similar sites, according to the local normal things happening, thus leachate quantity calculation suggested that using the empirical formula method[12].

### 5. Conclusion and Discussion

With the application of membrane separation technology in landfill leachate treatment, more and more membrane concentrate will be produced, and the treatment of membrane concentrate will become an important issue of environmental security. Due to the complex composition of membrane concentrate and the high concentration of pollutants, the treatment is difficult and can only be handled by physical or chemical methods. Due to the recirculation of membrane concentrate, the effluent salinity of leachate may increase, which may affect the stability of the system and the stability of the landfill body. At present, more and more landfills begin to choose membrane reduction, evaporation, advanced oxidation and other processes, hoping to achieve zero discharge of wastewater through technological innovation. The membrane concentration can be further reduced by the membrane reduction process, but the direction of the wastewater after the reduction and the pollution of the membrane during the membrane reduction process cannot be solved[13]. There are many problems such as high investment, high energy consumption and serious equipment corrosion in evaporation process. Advanced oxidation has a certain
effect on membrane concentration, but the process alone cannot meet the standard of direct discharge. Incineration can be used for power generation projects built with waste incineration, but there may be problems such as furnace coking, slagging and corrosion. To sum up, the disposal of membrane concentrate is difficult to rely on a single process technology to achieve harmless treatment. In the future, the harmless treatment of the concentrated solution of landfill leachate membrane filtration should be realized by combining the advantages of different processes with the combination of various processes in order to break through the existing problems and bottlenecks of each process[14]. Advanced oxidation technology is a wastewater treatment technology with great potential. It breaks the existing characteristics of treating the symptoms but not the root cause. With the further research and development of the technology, the treatment conditions are more mild, and the investment and operation cost are more economical.

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