# Overview of landfill leachate treatment technology

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**Abstract:** Household waste is directly related to people's quality of life and urban environment. As people pursue higher and higher spiritual quality, people pay more and more attention to the treatment of domestic garbage leachate. At present, although China has made some achievements in the treatment of domestic waste leachate, there are still many problems, which need to be solved. In this paper, the treatment of domestic waste leachate will be elaborated.

**Key words:** Landfill leachate; Treatment technology; Chemical method; Biological treatment method.

## 1. Introduction

With the rapid development of our economy, the amount of urban garbage also increases with it. Most cities in China use sanitary landfill or incineration to dispose of waste, resulting to a large amount of landfill leachate. Landfill leachate contains a variety of pollutants, such as heavy metal ions and organic matter, which not only exist in the water for a long time and a wide range, but also do great harm. If not properly treated, it will cause serious pollution to the environment. The effective collection and treatment of landfill leachate has become an urgent problem to be solved in urban environment. The treatment technology of landfill leachate has become a hot spot and difficult point for researchers.

## 2. Production and characteristics of landfill leachate

Landfill leachate, also known as leachate or leachate, is an inevitable secondary pollutant in landfill[1], mainly from precipitation, water contained in garbage and organic wastewater generated by anaerobic decomposition of microorganisms [2].Landfill leachate is a highly concentrated organic wastewater. If it is discharged directly without treatment or fails to meet the discharge standards, it will cause serious pollution to the surrounding groundwater, surface water and soil.

The pollutant content of landfill leachate is affected by many factors, such as waste composition, landfill years, climatic conditions, and landfill design [3]. The characteristics of landfill leachate water quality can be summarized as follows:

There are many kinds of pollutants, complex components and high concentration.Liu Jun et al. used GC-MS to analyze the organic components in the landfill leachate, and founded that there were 63 organic compounds, most of which were difficult to biodegrade, such as phenols, heterocyclic, heterocyclic aromatic and polycyclic aromatic compounds, accounting for more than 70% of the organic components in the leachate [4].High concentration of organic matter, high concentration of COD and $BOD_5$, up to tens of thousands of mg/L.

The changes of water quality and quantity are complex.The composition and yield of landfill leachate also change with different hydrologic and climatic conditions, geological conditions, geographical location, structural mode and landfill time.The biodegradability decreased with the increase of landfill age.

Imbalance of nutrition ratio.The content of ammonia nitrogen in the leachate is high, the C/N value is often maladjusted, and the p is deficient. The proportion of micronutrients cannot meet the requirements of water treatment.

## 3. Disposal method of landfill leachate

Landfill leachate, as a by-product produced in landfill, has always been the focus and difficulty in domestic sewage treatment field because of its high concentration of organic matter and ammonia nitrogen.At present, the treatment of landfill leachate in China can be roughly divided into physical and chemical methods, biological methods and membrane methods. The three types of leachate treatment technologies are generally introduced as follows:

### 3.1 Physicochemical method

Physicochemical method has a good treatment effect on refractory organic matter, atmospheric nitrogen and chroma in leachate. The commonly used physicochemical method to treat landfill leachate includes adsorption

method, chemical precipitation method, REDOX method, blowing, membrane treatment and so on.

#### *3.1.1 Chemical precipitation method*

Chemical precipitation method is to add chemicals to the landfill leachate, so that it and some soluble substances in the leachate replacement reaction, generate insoluble salt precipitation, so as to reduce the dissolved pollutants in the water.The added chemical is called a precipitator.According to the properties of the insoluble salt produced, the chemical precipitation mainly includes hydroxide precipitation and sulfide precipitation.The commonly used precipitators are aluminum sulfate, ferric chloride and polyaluminum chloride.It is mainly used to remove chroma, heavy metal ions and turbidity of landfill leachate.

#### *3.1.2 Chemical oxidation method*

In the process of waste water treatment, the use of toxic and harmful substances dissolved in the waste water can be oxidized in the REDOX reaction, to transform it into non-toxic and harmless new substances, this method is called chemical oxidation method.The chemical oxidation method is mainly to remove the chroma and sulfide of the leachate and decompose the refractory organic matter in the leachate, so as to improve the biodegradability of the wastewater.Commonly used oxidants include ammonia, ozone, hydrogen peroxide, potassium permanganate and sodium hyponitine.

#### *3.1.3 Adsorption*

Adsorption method is a kind of processing technology that uses porous solid material with adsorption ability to remove trace dissolved impurities in water.The COD and ammonia nitrogen in leachate can be removed by adsorption. The commonly used adsorbents are granular activated carbon and powder activated carbon.The use of activated carbon on the leachate of pollutants treatment efficiency is high, the treatment effect is good, but the treatment equipment is simple, compact structure, but the treatment cost is high, easy to block, adsorption saturated adsorption material is difficult to regenerate, treatment, at present, most of the adsorption method as the end of the leachate advanced treatment process.

#### *3.1.4 Blow off*

Since ammonia nitrogen in the water mostly exists in the state of ammonia ion ($NH^{4+}$) and free helium ($NH_3$), and the two maintain a balance, ammonia escapes from the leachate by applying the physical effect of aeration and blowing after the pH value is increased.Blow-off is mainly used to remove high concentration of ammonia nitrogen in landfill leachate, so as to ensure the normal operation of subsequent biological treatment.The blown $NH_3$ should be recovered to prevent secondary pollution to the air.

### 3.2 Biological treatment

Compared with conventional physical and chemical methods, biological treatment has a higher removal effect on dissolved and colloidal organic compounds.The operating cost is relatively low;The good settling performance of the residual sludge is conducive to further dehydration.Therefore, at present, the treatment of landfill leachate mainly adopts biological method.Biological treatment can be divided into aerobic biological treatment method, anaerobic biological treatment method and aerobic - anaerobic combined treatment method.

#### *3.2.1 Aerobic treatment*

Aerobic treatment can effectively reduce COD and ammonia nitrogen, but also remove some pollutants such as iron and manganese.Aerobic treatment processes include: sequencing batch reactor (SBR), cyclic circulating activated sludge process (CASS), oxidation ditch, oxidation pond, etc.

Ehrig et al. [5]used activated sludge method to treat landfill leachate. The experiment showed that when $BOD_5$ load was 0.1kg$BOD_5$/kg MLSS/d, the effluent $BOD_5$ was less than 25mg/L.In the experiment, the high ammonia nitrogen load caused the accumulation of nitrite. When the ammonia nitrogen load was less than 0.03kg·$NH^{4+}$-N/kg MLSS/d, the nitrification process could be completely carried out. With the adaptation of microorganisms to the high ammonia nitrogen load, the ammonia nitrogen load could be increased to 0.1 kg $BOD_5$/kg·MLSS/d.

Mard et al.[6]found that for landfill leachate with COD of 4000~13000mg/L,BOD of 1600~11000mg/L and atmospheric nitrogen of 87~590mg/L, the removal rate of COD can be stabilized above 90% by aerobic activated sludge process.

Robinson[7] used continuous flow activated sludge to treat landfill leachate, and found that when the sludge age was less than 5 days, the treatment effect fluctuated greatly, and there were problems such as sludge swelling.When the operating temperature drops from $10^0$C to $5^0$C, the treatment effect is greatly affected.When the sludge age is more than 10 days, the BOD and COD of the treated effluent can be lower than 20mg/L and 150mg/L, respectively.However, it was found that when the ratio of N/BOD exceeded 36:100, the excess ammonia nitrogen could not be utilized by microorganisms and remained in the treated effluent.

Ying et al. [8]used the SBR reactor to treat the landfill leachate from a landfill in the United States, and found that the removal rate of total carbon in the leachate by the SBR reactor was above 95%.Harry et al. used the two-stage SBR method to treat landfill leachate. The BOD removal rate of the first stage SBR reactor could reach 98%, and the COD of the influent decreased from 5800mg/L to 112mg/L.After secondary SBR treatment, the effluent quality can meet the discharge standard.

Yalmaz et al. [9]conducted SBR biological denitrification of effluent from a landfill site in Istanbul after anaerobic biochemistry, and found that the ammonia nitrogen

concentration could decrease from 1000mg/L in the inlet to 5mg/L in the effluent within a 24h cycle.

Wang Xiansheng et al. [10]adopted the two-stage contact oxidation process to treat landfill leachate, packed the soft packing inside, the aerobic volume was 6.71L, the influent concentration of the contact oxidation tank was 3100~6100mg/L, the secondary effluent concentration was maintained at 1100mg/L~3000mg/L, and the COD removal rate was ensured at about 10%.

In general, aerobic treatment has poor performance when toxic metal substances exist, and when the external temperature decreases rapidly, it is difficult to maintain a high removal rate.Energy consumption and other shortcomings.

### *3.2.2 Anaerobic treatment*

Anaerobic treatment has a good effect on the treatment of high concentration organic wastewater, which has the advantages of high treatment load, low sludge production rate, low energy consumption and less land area.Anaerobic biological treatment technology mainly includes: UASB reactor, anaerobic biological filter, anaerobic pond, anaerobic contact method and new anaerobic baffle reactor, etc.The Water research Center in the United Kingdom uses UASB to treat leachate with COD >10000mg/L. When the load is 3.6~19.7 kg/($m^3$·d), the average mud age is 1.0~4.3 d, and the temperature is $3^0$C, the removal rates of COD and $BOD_5$ are 82% and 85%, respectively.

Xu Zhu [11]used upflow anaerobic biofilter to conduct continuous dynamic experiment on leachate from Chengdu landfill site.The results show that the upflow anaerobic biofilter is effective in treating landfill leachate.At medium temperature, the COD removal rate of landfill leachate with COD of 3000~8000mg/L can reach 95%, even at room temperature, the COD removal rate can reach 90%.The COD volume load of the reactor can reach more than 5kg/($m^3$·d).

J.G. enry et al.[12], University of Toronto, Canada, used an anaerobic filter at room temperature to treat leachate with landfill age of 1.5 years (COD of 14000mg/L,B/C of 0.7) and 8 years (COD of 4000mg/L,B/C of 0.5), respectively.When the volume load is 1.26~1.45kg/($m^3$ d) and the HRT is 24~96h, the COD removal rate can reach more than 90%.

Shen Yaoliang et al. [13]used an ABR reactor to treat the mixed liquid of leachate and municipal sewage from Qizishan domestic waste landfill in Suzhou.The results show that ABR can effectively improve the biodegradability of mixed wastewater.When influent BOD5/COD is 0.2~ 0.3, effluent BOD5/COD can be increased to 0.4~0.6.When the volume load is 4.71kgCOD/($m^3$·d), the rod-shaped granular sludge with good settlement and particle size of 1~ 5mm can be formed.The sludge concentration in each compartment was 20~38g /L.The pretreatment of mixed wastewater by ABR greatly improves the operational stability of the subsequent aerobic treatment facility.

The anaerobic treatment has the advantages of low energy consumption and simple operation, so the investment and operation cost are low. At the same time, the anaerobic treatment produces less residual sludge and requires less nutrients such as nitrogen and phosphorus. Many polymer organic matter which is difficult to be treated under aerobic conditions can be biodegraded during anaerobic treatment.But anaerobic biological method can't remove the nitrogen and phosphorus in the waste water, the boot process, operation and management more complex, poor health condition, especially the single use of anaerobic treatment of high concentration organic wastewater, treatment is not completely, the water of the organic matter concentration are still high, should not be directly discharged into rivers or lakes, so in the biological treatment technology of landfill leachate,Anaerobic processes alone are rarely used.The combined anaerobic and aerobic mode is often used to treat high concentration organic wastewater.The anaerobic section is used to remove most of the organic pollutants in the water, and the polymer organic matter that is difficult to degrade is decomposed at the same time. The aerobic section is used for further treatment of organic matter and treatment of hydrogen and phosphorus.

Physicochemical method is mainly used to remove chroma, SS, ammonia nitrogen, heavy metal ions, refractory COD and other pollutants in leachate.Compared with the biological method, the physicochemical method has the ability to withstand the impact load, and has a better effect on the removal of precious metal ions and organics which are difficult to be degraded by the biological method.In particular, it has a good removal effect on the "aged" leachate with high ammonia nitrogen content and low $BOD_5$/COD ratio, which is difficult for biochemical treatment.However, the cost of physicochemical treatment is high, and the treatment process needs to be further optimized. At the same time, the physicochemical treatment process such as adsorption and precipitation only transfers the pollutants, and the pollutants will eventually return to the landfill in the form of physicochemical sludge, resulting in the circulation of pollutants.Therefore, physicochemical method is often used in the pretreatment and advanced treatment of landfill leachate, and the main process of leachate is usually biological method.

## 3.3 Membrane treatment technology

Membrane technology is a water treatment method that uses a membrane to separate the solvent from the solute and particles. According to the force of solute or solvent passing through the membrane, membrane separation can be divided into reverse osmosis, ultrafiltration and microporous filtration.In recent years, in order to reduce the degree of water pollution as much as possible, membrane method has also been applied in the field of leachate treatment, among which there are many applications and studies abroad.Thmos of Germany used reverse osmosis and microfiltration for the purification of leachate. The characteristics of reverse osmosis membranes under different conditions were studied and it was indicated that more than 95% osmosis removal rate could be achieved by using high-pressure reverse osmosis up to 120bar and microfiltration combined with a

controlled crystallization process.A reverse osmosis unit was successfully used to continue the treatment of biochemical water at the Damsdorf landfill in Germany, and membrane separation technology has been used in several leachate treatment plants in the Netherlands and Switzerland.Foreign practice has proved that membrane technology is efficient and reliable to treat landfill leachate.Due to its extremely high cost, membrane technology can not be widely used in the treatment of landfill leachate at present stage.

### 3.4 Combined process flow

At present, due to the increasing environmental pollution, from the perspective of strengthening environmental protection, the state has issued the Pollution Control Standard of Household Waste Landfill; Quasi-Emission Standard (GB16889-2008), in which the total effluent nitrogen becomes an important index (40mg/L in non-sensitive areas, 20mg/L in sensitive areas).In order to meet the total nitrogen requirements in the new landfill leachate discharge standard, the original MBR process was further optimized and A secondary nitrification and denitrification process was added. As shown in Figure 1, the MBR process was optimized to A/O/O + A/O+ external ultrafiltration membrane (UF) to ensure the total nitrogen discharge of effluent reached the standard.

To sum up, the leachate treatment process is mainly "biological method + membrane treatment", and the leachate treatment technology can meet the discharge requirements of the 2008 "Domestic Waste Landfill Pollution Control Standard Discharge Standard".Among them, the biochemical treatment process can effectively degrade and eliminate the pollutants, and the membrane separation process can effectively separate and remove the non-biodegradable residual pollutants.

## 4. Conclusions and recommendations

Landfill leachate is a kind of high concentration organic wastewater with complex composition, and its treatment technology has advantages and disadvantages. It is difficult to make leachate discharge standard by using any treatment technology alone.Therefore, the treatment process must be developed from the single to the diversified, through the combination of processes to give full play to the advantages of each process, in order to achieve satisfactory results."Biological method + membrane treatment" process technology can meet the discharge requirements of 2008 "Domestic Waste Landfill Pollution Control standard Discharge Standard", but there are still some problems in the process of landfill leachate treatment.

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