DOI : [http://doi.org/10.22438/jeb/40/3\(SI\)/Sp-07](http://doi.org/10.22438/jeb/40/3(SI)/Sp-07)

Rapid decomposition method of landfill leachate in recycling stations

Paper received: 17. 04. 2018

Revised received: 25. 10.2018

Accepted: 03.01.

Authors Info

X. Zhan*, Z. Chen and P. Zhao

School of Environment and Civil Engineering, Jiangnan University, Wuxi, 214 122, China

Abstract

Aim: In order to solve the problem that the decomposition speed of leachate in landfill is slow and the concentration of pollutants is still in excess of the standard under the traditional method, a rapid decomposition method of leachate in landfill is proposed.

Methodology: A decomposition method for the landfill leachate in the recycling station based on microwave digestion is proposed. The indexes of chemical oxygen demand, ammonia nitrogen, lead, arsenic, mercury, cadmium, chromium, and other heavy metal ions in the filtrate determined the optimal conditions for the use of oxidants, flocculants and adsorbents in the combined methods of chemical oxidation, flocculation sedimentation and adsorption filtration.

Results: The experimental results show that using the proposed method for landfill leachate decomposition results in faster decomposition rate, and the concentration of pollutants in the landfill leachate after decomposition is low.

Interpretation: According to the best conditions of use, rapid decomposition of landfill leachate can be achieved.

Key words: Adsorption filtration, Decomposition, Landfill leachate, Rapid decomposition, Recycling stations

*Corresponding Author Email :
zhanxu_010@163.com

Edited by

Prof. Ahmed Jalal Khan Chowdhury

Reviewed by

Dr. Yifeng Wu
Dr. Zhihua Yang

Citation: Zhan, X., Z. Chen and P. Zhao: Rapid decomposition method of landfill leachate in recycling stations. *J. Environ. Biol.*, **40**, 448-459 (2019).

Introduction

Landfill leachate is a highly concentrated organic wastewater that is formed by filtering out or decomposing the garbage after landfill operation and natural precipitation (Zolfaghari *et al.*, 2016). The pollutant concentration is high, and the composition is complex. If landfill leachate is not properly treated, it will seriously pollute the soil, atmosphere, surface water and groundwater, resulting in secondary pollution. These characteristics make leachate treatment a worldwide problem (Azadi, 2017; Asghar *et al.*, 2018; Shabi *et al.*, 2018). In recent years, with the development of economy and expansion of the city scale, the amount of waste generated in production and life has gradually increased, resulting in an augment in the amount of landfill leachate, and the environmental pollution caused by landfill leachate has become increasingly serious (Huda *et al.*, 2017; Khattak *et al.*, 2018). Recycling stations are important sites for garbage storage. Suppression of landfill leachate pollution in recycling stations has become one of the most important issues to be solved in the world (Li *et al.*, 2017; Bumidin *et al.*, 2018). Landfill leachate decomposition as an important means of realizing landfill leachate treatment has received more and more attention from relevant experts and scholars, and its research has been deepened to produce some more mature theories and applications (Zolfaghari *et al.*, 2018; Qiao, 2018).

With the increasing emphasis on urban environmental issues, landfill leachate decomposition is an important method to reduce garbage pollution and improve urban environmental quality has become a key topic for related experts and scholars (Kim and Ahn, 2016; Cho, 2017; Kassim *et al.*, 2018). At present, there are still some deficiencies in the landfill leachate decomposition treatment method in the recycling stations. For example, a method of landfill leachate treatment based on catalytic wet oxidation method was mentioned. This experiment was carried out at H_2O_2 a high temperature and high pressure reactor, using Fe^{2+} as catalyst and as oxidant. Mean while, the impacts of temperature, residence time, catalyst types and its dosing quantity on the degradation of leachate were researched. The results showed that the COD removal rate of the effluent reached 91%, however, this method is complex and is difficult to implement (Cai *et al.*, 2016; Howlader *et al.*, 2018). Also, a short-cut nitrification-anaerobic ammonia oxidation combined process for deep treatment of landfill leachate was introduced. UASB (upflow anaerobic sludge blanket)-A/O (anoxic/aerobic) reactor-ANAMMOXR (anaerobic ammonia oxidation reactor) process and a short-cut nitrification-ANAMMOX (anaerobic ammonia oxidation) were utilized to deeply treat the mixed land leachate and domestic sewage (Wu *et al.*, 2016; Khan *et al.*, 2018). However, this method requires more materials for processing, leading to a slower treatment rate.

In addition, a response surface method was combined with the electro-oxidation-flocculation coupling process for

advanced treatment of landfill leachate (Hou *et al.*, 2017; Li *et al.*, 2018). Through simulation and analysis of variance, a quadratic response surface model with significant levels was obtained (Ahamed *et al.*, 2017; Allahdadi and Li, 2018; Guerrini *et al.*, 2018; Mahmood *et al.*, 2018; Sultana *et al.*, 2018). By analyzing the response surface, the optimal reaction conditions for COD removal were obtained, and the landfill leachate treatment was implemented according to the optimal conditions. However, the treatment process of this method is relatively complex, resulting in a slower processing speed. Two times model and regression model were used to study the variation of operating parameters with time and influence on COD, and the physical and chemical characterization of leachate and solid waste was carried out by standard analysis method. Through experiments, it was proved that most of the organic and inorganic pollutants in the leachate decreased with time, and the alkalinity increased, which indicated the leachate cycle bioreactor has excellent performance, but this method is more complex and difficult to implement (Lohchab and Singh, 2017). Under anaerobic condition, the collected leachate was recycled in a cylindrical bioreactor using domestic solid waste as raw material, and various parameters of leachate collected from outlet were analyzed. This method can promote organic degradation of garbage, but the concentration of pollutants after decomposition is still beyond the standard (Rastogi *et al.*, 2016). The purpose of this study is to emphasize the effect of leachate recirculation on stabilization of refuse in simulated bioreactor. By measuring water quality of leachate regularly, the operating parameters such as pH, VFA and alkalinity and so on are found in the optimum range of anaerobic degradation. The experimental results show that the removal rate of COD is 96%, which indicates that the leachate circulating bioreactor is an effective method for the treatment of domestic waste, but the rate of decomposition is slow (Snehlata *et al.*, 2015).

In view of the above problems, a method for decomposition of landfill leachate in a recycling station based on microwave digestion is proposed. The overall structure is as follows: By analyzing the amount and quality of landfill leachate to clarify the impact of landfill leachate on the environment and analyze the necessity of landfill leachate decomposition treatment; The optimum amount of oxidant, the optimal ratio and concentration of flocculant were determined, and the best filter and adsorbent were selected to achieve the decomposition of landfill leachate; The experimental results and analysis demonstrate the effectiveness of landfill leachate decomposition method based on the microwave digestion. Based on the summarization of existing research, the prospects are put forward.

Materials and Methods

Amount and quality of landfill leachate: Landfill leachate production is affected by many factors, and its change is irregular.

The landfill leachate comes from the following five aspects, and the main influencing factors on the amount of leachate production (Lang *et al.*, 2017) are described in Table 1.

Infiltration of precipitation. Precipitation includes rainfall and snowfall and leaching of rainfall is the main source of leachate production; Inflow of external surface water, including surface runoff and surface irrigation; Infiltration of groundwater. When the level of the leachate in the landfill is lower than the off-site groundwater level and no anti-seepage system is installed, groundwater may seep into the landfill; The water contained in the trash itself. This includes the amount of moisture that the waste itself carries and the amount of adsorption from the atmosphere and rain. When the waste water content is 47%, 0.0722 tons of leachate can be produced per ton of waste; After landfilling, water produced by anaerobic decomposition of microorganisms. The organic components of the waste produce moisture when decomposed in the recycling station.

The amount of landfill leachate is generally calculated based on the water balance method at the recycling station or using an empirical formula (Rhr *et al.*, 2017). According to the main influencing factors of infiltration, the amount of leachate can be calculated by performing water balance at the recycling station.

Water balance method: the amount of leachate = inflow of water - outflow of water.

The amount of leachate can be accurately calculated by the above equation, but there are many uncertain parameters in the calculation process of evaporation amount and runoff. It is difficult to obtain satisfactory results in actual calculation. The commonly used formula is the leaching coefficient method (Hu *et al.*, 2017):

$$Q = (C_1 A_1 + C_2 A_2) I / 1000 \quad (1)$$

In the above equation, A_1 denotes the area that is being landfilled; A_2 denotes the area that is landfilled; C_1 is the exudation rate of A_1 , generally in the 0.4 - 0.7 range, and the standard value is 0.5; C_2 is the exudation rate of A_2 , and is generally 0.2-0.4, and the standard value is 0.3; I is the rainfall intensity. Nowadays, urban landfill decomposing has become the main waste disposal method in China and even in the world. The water quality of landfill leachate in some cities in China is shown in Table 2. The typical domestic and foreign landfill leachate pollutant content is shown in Table 3. Among them, the pH value is constant, its unit is o, and the rest of the unit is mg L^{-1} .

Due to regional differences, living standards of urban residents, and different living habits of people, the composition of urban garbage in various countries and regions is different, and the composition of different garbage components leads to great differences in the quality of landfill leachate. The composition of domestic and international urban wastes is listed in Table 4. The domestic waste contain high levels of organic matter, which makes the content of CODcr and BOD in landfill leachate higher in China.

If landfill leachate directly enters the environment without treatment, the surface water and groundwater will be seriously polluted. Once the leachate containing high concentrations of organic pollutants and reduced metals enters the surface water, it will consume a large amount of oxygen in the water and eventually kill water aerobics organisms. Toxic carcinogens and heavy metal substances will endanger human health through food chain. And when leachate leaks into groundwater, the underground water used for drinking water gets polluted. In order to protect the environment, the treatment of landfill leachate is essential.

Table 1: Main factors affecting landfill leachate production

Main factor	Sub factor
Precipitation	Amount, intensity, frequency of precipitation
Groundwater intrusion	Flow direction, flow rate, location of groundwater; engineering geology of the recycling station; bottom anti-seepage system of the recycling station
Surface runoff and evaporation	Surface topography, roof material, earth cover material, soil and initial moisture conditions of landfill waste; temperature, wind, vegetation, solar radiation, etc.
Garbage composition	Initial moisture content, layer height and uniformity, degree of compaction.

Table 2: Quality of landfill leachate in the city of China

Index	Shanghai	Guangzhou	Shenzhen	Nanchang	A city in Taiwan
CODcr (mg l^{-1})	1500-15000	1400-60000	50000-80000	1000-8000	4000-37000
BOD ₅ (mg l^{-1})	200-4000	400-11000	2000-35000	600-6000	600-28000
TN (mg l^{-1})	100-3000	150-4000	400-2600	500-800	200-2000
SS (mg l^{-1})	30-500	200-5000	2000-7000	100-600	500-2000
NH ₃ -N (mg l^{-1})	60-2800	160-3000	500-2400	400-500	100-1000
pH value o	5.0-7.3	6.5-9.0	6.2-6.6	6.5-8.0	5.6-7.5

Table 3: Typical values of pollutants in municipal landfill leachate at home and abroad

Index	Concentration (threshold)	Index	Concentration (threshold)
pH value o	5.2-8.2	Cu (mg l ⁻¹)	0.01-0.3
CaCO ₃ (mg l ⁻¹)	37-14000	Fe (mg l ⁻¹)	0.3-2050
SS (mg l ⁻¹)	100-700	Zn (mg l ⁻¹)	0.01-130
Ts (mg l ⁻¹)	500-15800	Ammonia nitrogen (mg l ⁻¹)	1-3400
Cd (mg l ⁻¹)	0.005-0.007	Nitrate nitrogen (mg l ⁻¹)	0.1-10
As (mg l ⁻¹)	0.006-0.2	Total phosphorus (mg l ⁻¹)	0.6-75
Ba (mg l ⁻¹)	0.1-0.3	TOC (mg l ⁻¹)	196-23000
Pb (mg l ⁻¹)	0.002-12.3	BOD ₅ (mg l ⁻¹)	11-38000
Ca (mg l ⁻¹)	29-4300	CODcr (mg l ⁻¹)	20-70000
Cr (mg l ⁻¹)	0.002-1.0	Organic nitrogen (mg l ⁻¹)	3-770
Co (mg l ⁻¹)	0.01-1.8	Kjeldahl nitrogen (mg l ⁻¹)	2-762

Table 4: Waste composition in the city at home and abroad

Composition	Organic matter/%	Paper/%	Glass/%	Metal /%	Plastic /%	Fabric /%	Inorganic waste /%
New York	22	44.8	11.6	8	5.1	4	4.5
Paris	28.8	25.3	13.1	4.1	14.3	7.1	7.3
London	28	37	10.89	6.0	5.2	3.4	9.6
Beijing	56.1	11.76	3.84	1.69	12.6	2.75	8.32
Shanghai	58.55	6.68	4.05	2.0	11.84	2.26	7.54
Dalian	73.39	3.37	2.56	0.51	5.66	1.63	4.41

Experimental materials and methods: In order to realize the rapid decomposition of landfill leachate in the recycling station, the experimental materials selected mainly include landfill leachate, oxidants, flocculants, zeolites (adsorbents), common chemicals, biological reagents drugs, and WNIX-III-B microwave digestion equipment, HP6890GC/5973MS (Agilent, USA) and commonly used glass equipment. The leachate was collected from a city recycling station, and its pH value ranged between 6-8. It was dark brown opaque liquid with odor, and passed through impermeable membrane layer (the base waterproof, seepage isolation filter facilities covered on the surface and garbage when landfilled), the amount was about 300 m³ d⁻¹.

In order to screen oxidants, the chemical oxygen demand (COD) is determined according to the microwave digestion method (Ferreira-Pinto *et al.*, 2017). The effect of nearly ten commercially available chlorine-containing and oxygen-containing oxidants on leachate treatment was investigated. The chlorine-containing oxidant has a good treatment effect on the COD of leachate, and the color of leachate becomes significantly lighter, and can be used for the treatment of leachate. According to the method in GB 10124-88 "Uniform Corrosion Full Leaching Experiment in Metallic Materials Laboratory", the chlorine-containing oxidant was evaluated. The evaluation results are expressed with the metal corrosion rate (*R*).

$$R = 8.76 \times 10^7 \times (M - M_i) / (S \times t \times d) \quad (2)$$

In the above equation, *R* denotes the corrosion rate, *M* denotes

the weight of the metal sheet before experiment; *M_i* denotes the weight of the metal sheet after the experiment; *S* denotes the total surface area of the metal sheet; *t* denotes the experimental time and *d* denotes the density of the metal material.

As shown in Table 5, the corrosion evaluation results of the composite chlorine-containing oxidants are based on the corrosion grade standard (Ilhan *et al.*, 2017; Shaikh *et al.*, 2017). This oxidant has medium or lower corrosion level to stainless steel, carbon steel, copper and aluminum.

In summary, the composite chlorine-containing oxidant was selected as the oxidant for leachate treatment. Highly absorbent media include activated carbon, zeolites, fly ash, lime, diatomaceous earth and kaolin (Xu, 2018).

To achieve landfill leachate decomposition treatment, it is necessary to determine the optimal amount of oxidant. During the experiment, 13 Erlenmeyer flasks (250 ml) are used. And 50 ml of leachate stock solution and 150 ml of distilled water are added, followed by 0, 0.02, 0.04, 0.06, 0.08, 0.10, 0.12, 0.14, 0.16, 0.20, 0.30, 0.50, 0.70 g of oxidant respectively, and then stirred at a speed of 100-200 r min⁻¹ for 1 min. After a reaction time of 30 min, the solution was taken for COD determination. The change of COD in leachate was recorded to determine the relationship between changes and the optimal dosage.

In order to determine the optimal proportion and concentration of flocculant used in landfill leachate treatment, an

Table 5: Corrosion evaluation results of composite chlorine-containing oxidants on metallic materials

Material category	Corrosion rate / (mm a ⁻¹)	Corrosion level / level
Stainless steel	0.003	No corrosion
Carbon steel	0.9695	Moderate corrosion
Copper	0.1524	Moderate corrosion
Aluminum	0.0983	Mild corrosion

Table 6: COD concentration measured with the microwave digestion method

Number	V _a /ml	V _b /ml	X / %	mg ⁻¹	COD
1	50	150	0	0	63523
2	50	150	0.02	0.01	61827
3	50	150	0.04	0.02	60214
4	50	150	0.06	0.03	59462
5	50	150	0.08	0.04	54978
6	50	150	0.10	0.05	54913
7	50	150	0.16	0.08	55128
8	50	150	0.20	0.1	55113
9	50	150	0.30	0.15	55161
10	50	150	0.70	0.35	55243

Fig. 1 : Relationship between the percentage of used oxidant (X) and COD of leachate after treatment. **Fig. 2 :** Comparison of adsorbed heavy metal ions of seven different adsorbent filters determined by Buchner funnel filtration.

orthogonal test method is used (Qing *et al.*, 2017). A total 100 ml of leachate stock solution was loaded in the conical flask, chitosan, polyaluminum, and ferric chloride of different mass to concentration ratio was added as well, then the mixture was stirred at 100-150 r min⁻¹ for 2 min; after standing for 20 min, the supernatant is taken to determine COD and ammonia nitrogen value. By analyzing the effect of different proportions of chitosan, polyaluminum, and ferric chloride and concentration of use on the COD and ammonia nitrogen after leachate treatment, the optimal proportion and concentration of the flocculant composition are determined.

In order to determine filter material adsorption value in the

treating process of landfill leachate, the adsorption filter material needs to be pretreated. Seven different types of dry zeolites were weighed in 100 g and put in a 500 ml beaker, and 150 ml of deionized water was added. After fully immersing for 1h, the excess moisture was filtered with dry gauze. In order to better screen the filter material, two methods was used for adsorption filtration, and the results of filter adsorption values of two methods was compared to further determine the adsorbent so as to achieve a better adsorption filtration effect.

The first method: direct immersion (Chen *et al.*, 2016). The pretreated filter material 1008 was weighed into a 1 l conical flask, and then 150 ml of landfill leachate after being treated with

Table 7: Three-factor three-level orthogonal table

Level	Chitosan /%	Polymer aluminum /%	Ferric chloride /%
1	0	0	0
2	0.5	0.5	1.0
3	1.0	1.0	2.0

Table 8: Orthogonal experimental results of COD concentration after flocculation

Number	Chitosan /%	Polymer aluminum /%	Ferric chloride /%	COD / (mg l ⁻¹)
1	1	1	1	62133
2	1	2	2	53353
3	1	3	3	48864
4	2	1	2	53262
5	2	2	3	60103
6	2	3	1	57814
7	3	1	3	58231
8	3	2	1	50864
9	3	3	2	60263
k ₁	54872	57874	59341	
k ₂	57060	57173	55627	
k ₃	58856	55645	55728	
R	4029	2229	3613	

1% helium oxidizer is added and immersed for 24 hr. When immersed, shaking from time to time to facilitate adequate filtration, and then COD, ammonia nitrogen, lead, arsenic, mercury, cadmium, chromium and other heavy metal ions were determined.

Second method: A 100 g of pretreated filter material was weighed and positioned into a 65 mm Buchner funnel, and then 150 ml of the landfill leachate after being treated with 1% helium oxidizer was added and naturally filtered three times. Afterwards, COD, ammonia nitrogen, lead, arsenic, mercury, cadmium, chromium and other heavy metal ions were measured (Benyoucef *et al.*, 2016).

The filter adsorption pollutant concentration value can be expressed as:

$$X = \frac{\Delta COD \times 150 \times 10^{-3}}{100} \quad (3)$$

In the above equation, ΔCOD represents the amount of COD change after landfill leachate is filtered by the filter material. The concentration of pollutants in landfill leachate is determined and the microwave digestion method is used to measure the COD. The specific process is described below:

Accurately draw 5.00 mL of uniform water sample into the digestion tank, add 1g of mercury sulfate (don't add into water sample without chlorine ion), add 5.00mL potassium dichromate digestion solution, 5.00mL sulfuric acid-silver sulfate solution. Place the digestion tank evenly into the periphery of the glass

turntable of the furnace chamber. Digestion time $W=n+10n+20$, where n is the number of samples. After the digestion is complete, remove the digestion tank from the fire. When the liquid in the tank cools to room temperature, measure the COD value by titration. Titration: Add 2 to 3 drops of ferrioxide indicator, then add the ferrous ammonium sulfate standard solution for titration. After the color of the solution changes from yellow to blue-green, and turns into reddish-brown color, the titration is finished. And the amount of the ammonium ferrous sulfate standard solution used is recorded and utilized to calculate the COD value according to the following equation.

$$COD_{Cr} (O_2, mg L^{-1}) = \frac{(V_0 - V_1) c \times 8 \times 1000}{V} \quad (4)$$

Where: c is the concentration of ammonium ferrous sulfate standard solution; V_0 is the amount of ammonium ferrous sulfate standard solution used when titrating blanks; V_1 is the amount of ammonium ferrous sulfate standard solution used when titrating the water sample; V is the volume of the water sample; 8 represents molar mass of oxygen (1/2O). Through the above experimental methods, COD concentration values are measured by the microwave digestion method. The results are shown in Table 6.

In the above table, V_a is the volume of leachate measured; V_b is the volume of deionized water added to dilute the leachate; X is the ratio of the oxidant added to leachate of 100 ml; m is the mass of the oxidant. According to the above Table, a

Table 9: Results of $\text{NH}_4^+\text{-N}$ concentration after flocculation

Number	Chitosan /%	Polymer aluminum /%	Ferric chloride /%	$\text{NH}_4^+\text{-N}$ (mg l^{-1})
1	1	1	1	2542
2	1	2	2	1931
3	1	3	3	1715
4	2	1	2	1532
5	2	2	3	2170
6	2	3	1	1932
7	3	1	3	1655
8	3	2	1	1844
9	3	3	2	1688
k_1	2063	1910	2107	
k_2	1879	1983	1715	
k_3	1731	1776	1844	
R	332	207	392	

Table 10: COD results after direct immersing using seven filter materials

Filter number	COD before filtering (mg l^{-1})	COD after filtering (mg l^{-1})	Change of COD (mg l^{-1})	COD adsorption of filter (mg g^{-1})
1	60511	52769	7742	11.5
2	60511	49836	10675	16.1
3	60511	54045	6466	9.7
4	60511	48376	12135	18.3
5	60511	54486	6025	9.0
6	60511	52978	7533	11.1
7	60511	48577	11934	17.8

graph describing the relationship between the percentage X of the oxidant and the treated leachate COD is shown in Fig. 1.

According to Table 6 and Fig. 1, when $X = 0.1$, the COD value is minimum, and COD value can be reduced 8609.47 mg/La to the maximum, and from $X = 0.1$, the curve has upward fluctuations, but the overall fluctuation is not large, showing a gentle trend. The results show that the use of oxidant has a non-positive increasing relationship with the effect of leachate treatment COD. With the increasing use of oxidants, COD gradually decreases; when the amount of oxidant is higher than 0.1% (w/w), COD tends to be constant. The main reason why the COD value tends to be fixed may be that the oxidation potential of oxidant is limited, and it is impossible to completely oxidize all organic pollutants. Even if more oxidants are added, chemical oxidation treatment methods cannot completely eliminate all organic pollutants in landfill leachate. Considering factors such as treatment results and economic costs, the optimum amount of oxidant is 0.1% (w/w).

Using three-factor three-level L_9 (3^4) orthogonal test method, the results are as follows: The ratio of three factors, chitosan, polyaluminum, and ferric chloride are determined as shown in Table 7.

Then the landfill leachate is treated according to different proportions. The results of COD concentration after treatment are

shown in Table 8. The results of $\text{NH}_4^+\text{-N}$ concentration after treatment are shown in Table 9. Among them, R represents a range, which is the difference between the maximum value and the minimum value of mean value, and k_i represents the mean value.

From the results in Table 8, it can be seen that the range R of chitosan is relatively larger than others. The ratio with the minimum k_i should be regarded as the optimal flocculation ratio, then the chitosan is taken as k_1 , the corresponding mass percent concentration is 0; the polymeric aluminum is taken as k_3 , and the corresponding mass percent concentration is 1.00%; ferric chloride is taken k_2 , the corresponding mass percentage concentration is 0.10%.

Table 9 shows that the range R of ferric chloride was relatively large compared to others. The ratio with minimum k_i was regarded as the optimal flocculation ratio, chitosan was taken as k_3 , the corresponding mass percentage concentration was 1.00%, the polymerized aluminum was taken as k_3 , and the corresponding mass percentage concentration was 1.00%; ferric chloride was taken k_2 , and the corresponding mass percentage concentration was 0.10%.

Comprehensive analysis of COD and $\text{NH}_4^+\text{-N}$ changes in these two indicators, the best treatment effect of flocculant was chitosan, polyaluminum, ferric chloride of mass ratio 1:1:0.1, the

Table 11: Results of ammonia nitrogen after direct immersing using seven filter materials

Filter number	Ammonia nitrogen before filtering (mg l^{-1})	Ammonia nitrogen after filtering (mg l^{-1})	Change of ammonia nitrogen (mg l^{-1})	Ammonia nitrogen adsorption of filter (mg g^{-1})
1	2471	410	2061	3.1
2	2471	465	2006	3.0
3	2471	422	2049	3.1
4	2471	518	1953	2.9
5	2471	771	1700	2.5
6	2471	730	1741	2.6
7	2471	583	1888	2.8

concentration was about 2%.

Seven different types of filter materials were used to filter and adsorb leachate by two methods.

By analyzing Table 10 and Table 11, it can be seen that among seven different kinds of adsorbent filter materials, the materials with higher COD adsorption values were type 4 and 7, and the adsorption values reached 18.3 mg g^{-1} and 17.8 mg g^{-1} . Adsorption values for ammonia nitrogen were higher on type 1, 2, 3 and 4, and the adsorption value reached 2.9 mg g^{-1} to 3.1 mg g^{-1} . Among seven different adsorbent filters, the highest adsorption values for COD were type 2 and 4. The adsorption values reached 10.3 mg g^{-1} and 10.6 mg g^{-1} . Adsorption values for ammonia nitrogen were higher in type 1 and 4, and the adsorption values reached 3.0 mg g^{-1} and 2.6 mg g^{-1} , respectively.

The adsorption results of heavy metals, lead, cadmium, chromium, arsenic, mercury etc. for seven different adsorbent filter materials are shown in Fig. 2. The adsorption material number is a constant, and its unit is m.

Fig. 2 shows that among seven different kinds of adsorbent materials, type 1 and 3 had higher values of lead adsorption, (0.24 mg l^{-1} and 0.26 mg l^{-1}). Adsorption values of type 3, 2 and 5 for cadmium were higher, and the adsorption values reached 0.9 mg l^{-1} and 0.8 mg l^{-1} . Adsorption values for chromium of type 3 and 4 appeared to be superior than others, with adsorption values of 4.65 mg l^{-1} and 4.05 mg l^{-1} . Adsorption values of type 6, 2 and 4 for arsenic were higher, with adsorption values of 4.05 mg l^{-1} , 3.15 mg l^{-1} , and 3 mg l^{-1} . Adsorption values of type 6 and 4 for mercury were higher, and the adsorption values were 0.8 mg l^{-1} and 0.71 mg l^{-1} .

Thus, considering the adsorption of seven kinds of filter materials on leachate COD, ammonia nitrogen, lead, tin, chromium, arsenic, and mercury, and taking into account the influence of filter material particle size, filtration speed, and other factors, and type 4 filter material was selected as the best filter material, its COD adsorption value was about 18.2 mg g^{-1} , ammonia nitrogen adsorption value was about 2.9 mg g^{-1} , lead adsorption value is about 0.21 mg L^{-1} , cadmium adsorption value is about 0.05 mg L^{-1} , chromium adsorption value is about 4.05 mg l^{-1} ,

the arsenic adsorption value is about 3 mg l^{-1} , and the mercury adsorption value is about 0.71 mg l^{-1} .

By analyzing the amount of landfill leachate and leachate water quality, the leachate pollutant content was determined, by preparing related materials, experimental oxidant optimum dosage, optimal proportion of flocculant and concentration, the best filter material was selected. According to the experimental results, rapid decomposition of landfill leachate was achieved.

Results and Discussion

In order to analyze the decomposition results of the landfill leachate decomposition method in a recycling station based on the microwave digestion method, an experiment was conducted. The experiment used landfill leachate collected in a city's garbage collection station as an experimental material and utilized the above method to achieve decomposition of landfill leachate. The experimental data of landfill leachate decomposition process were collected, and the experimental results were compared with experimental results of the leachate decomposition method based on catalytic wet oxidation method and the leachate decomposition method based on short-cut nitrification-anaerobic ammonia oxidation combined process. The effectiveness and feasibility of the leachate decomposition method based on microwave digestion was determined. The results obtained are as follows.

Table 12 shows that as the amount of decomposed landfill leachate increased, the reaction time of leachate, oxidant, and adsorbent increased in the decomposition process and the decomposition completion time also increased. The decomposition time of the landfill leachate decomposition method based on the microwave digestion method was shorter than the decomposition method based on the catalytic wet oxidation method and the method based on the short-cut nitrification-anaerobic ammonia oxidation combined process. A linear relationship was found between the amount of leachate and completion time, indicating that the decomposition method of landfill leachate based on microwave digestion method was faster and the decomposition effect was relatively stable.

Table 12 : Comparison of decomposition completion time of different methods

Leachate /mL	P/min	Q/min	W/min
100	5.6	6.3	5.8
150	6.8	7.8	7.7
200	8.1	9.3	9.5
250	9.2	10.9	11.3
300	10.4	12.4	12.9
350	11.6	14.0	14.2
400	12.7	15.6	16.0
450	13.9	17.1	17.1
500	15.1	18.3	18.7

Decomposition of landfill leachate was tested using different methods. Decomposition of landfill leachate reduced the content of leachate pollution. In the experimental process, the leachate collected from different recycling stations was divided into groups, and the leachate of each group was decomposed using different methods to analyze the content of pollution indicators in landfill leachate. The obtained results are shown in Fig. 3.

The COD_{Cr}, CaCO₃ and SS concentration in the leachate decomposed by the microwave digestion method were less than that of leachate decomposition method based on catalytic wet oxidation method and the combination of short-cut nitrification and anaerobic ammonia oxidation. It shows that the decomposition of landfill leachate based on microwave digestion method had lower COD_{Cr}, CaCO₃ and SS concentration after decomposition, and the decomposition effect was better. In the process of decomposing leachate, for the decomposition method of landfill leachate based on microwave digestion method, the optimum amount of oxidant, the optimal ratio and concentration of flocculant, and the best filter material and adsorbent were determined, which increased the quality of leachate decomposition and reduced the content of leachate pollution indicators.

The pH value, as an important indicator for evaluating water quality, was measured for leachate decomposed with different methods. The pH of leachate after decomposition was analyzed to determine the leachate quality after decomposition by different methods. The results obtained through experiments are shown in Fig. 4.

The pH value of the leachate after decomposing by microwave digestion method was around 7 and the fluctuation range of pH value was small, the pH value of leachate decomposition method based on catalytic wet oxidation was around 6-7, the pH value of leachate decomposition method based on short-cut nitrification-anaerobic ammonia oxidation combined process was around 5.8-7.3. This shows that the water quality of leachate treated with decomposition method based on microwave digestion method was better.

The decomposition speed of landfill leachate was slow and the concentration of pollutants was still over the standard after decomposition, a fast decomposition method of landfill leachate based on microwave digestion method is proposed. The experimental results showed that the proposed method was faster than the traditional method, and the concentration of pollutants was lower, which shows that the proposed method was more superior than the traditional method.

The landfill leachate decomposition treatment is a key point in waste treatment and is of great significance in improving the quality of the environment. Among the leachate decomposition treatment technologies, most of the leachate decomposition treatment in China is simple application of wastewater treatment technology, which makes the treatment water quality unstable and the concentration of organic pollutants higher, and the treatment system has a poor ability to withstand impact loads, especially ammonia nitrogen of higher concentrations is not handled properly (Rastogi *et al.*, 2016; Snehlata *et al.*, 2015). Aiming at the problem that the current landfill leachate decomposition treatment method has a slow processing speed and the concentration of pollutants in the leachate after treatment is still high, a rapid decomposition method of landfill leachate in a recycling station based on microwave digestion method is proposed. The experimental results showed that the proposed method has a faster leachate treatment rate and a lower concentration of pollutants in the leachate after treatment (Cai *et al.*, 2016).

At present, variety of water treatment methods are used to decompose and treat landfill leachate in recycling stations internationally. The decomposition treatment of domestic landfill leachate is generally based on biological treatment, and the research and operation of physical and chemical methods are mainly international. The leachate treatment technology of China's recycling stations is still in the exploratory stage. To build a standardized municipal waste sanitary landfill, it is necessary to conduct more in-depth, more comprehensive, and more systematic research on leachate treatment technologies.

Fig. 3 : Comparison of (a) COD_{Cr}; (b) CaCO₃ and (c) SS concentration in leachate after decomposition by different methods.

Fig. 4 : Leachate decomposition method based on (a) catalytic wet oxidation; (b) microwave digestion; (c) short-cut nitrification-anaerobic ammonia oxidation combined process.

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