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Influence of landfill leachate on water environmental quality of urban rivers

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ABSTRACT

To improve the quality of the urban water environment, the influence of landfill leachate on the quality of the urban river water environment was studied. Two garbage transfer stations *A* and *B* in H city were taken as research areas, and the common river *C* near the two garbage transfer stations was taken as a fixed-head boundary. The influence of landfill leachate on the water environment quality of urban rivers was studied from three aspects: the influence of surface water environment quality and the influence of leachate on groundwater environment quality of rivers. The results showed that chemical oxygen demand (COD), biochemical oxygen demand (BOD_5), ammonia nitrogen, TN and TP in the mixture of leachate and cleaning water of the two garbage transfer stations exceeded the standard several times. The flushing water and leachate of the two garbage transfer stations were mixed into the urban sewage pipe network or the rain-sewage mixed pipe network. The leachate had unbalanced nutrition, alkalinity, high ammonia nitrogen content, and high chroma, and contained both of them. There are a large number of refractory organic matter and a variety of organic pollutants which can reduce the performance of the organism. A variety of pollutants from leachate were detected in the upper stagnant water and diving water samples in H city, but the pollutant content in the diving water samples was lower than that in the upper stagnant water samples of surface water and the diving water samples, the content of Fe and Mn was very high and the pollution was serious. Thirteen kinds of organic pollutants from leachate were detected in surface water of H city, the discharge load of compressor refuse transfer station was the highest, and the COD load of pollutants was the highest, followed by BOD_5. The results show that landfill leachate can increase the content of organic pollutants in surface water and groundwater, increase a load of organic pollutants in the river water environment, and reduce the quality of the urban river water environment.

Keywords: Garbage; Leachate; Urban river; Water environment quality; Surface water; Diving layer; Heavy metals

1. Introduction

At present, the disposal of domestic waste in most cities in China is still in its infancy. Only 2.3% of the annual output of garbage can be treated harmlessly. Most of the garbage can only be transported to the suburbs for landfill decay [1]. A direct consequence of landfill disposal is that a large number of garbage is caused by the absence of any anti-seepage measures. Leachate with very poor water quality causes serious pollution to soil and water body and directly threatens human health [2].

Landfill leachate is formed in the process of landfill or landfill by rainwater infiltrating into the garbage, which carries soluble substances. It is the flow part of toxic substances in the garbage dump area or landfill [3]. It contains a high concentration of inorganic and organic compounds. In the process of landfill treatment, the anti-seepage lining is destroyed due to mechanical and natural effects, or the collection and drainage system of landfill leachate loses its

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function due to corrosion [4], which will lead to leakage, overflow or inadequate treatment of landfill leachate, and make it toxic. Quality enters the surrounding environment and pollutes the surrounding soil, water and atmosphere [5]. In China and abroad, incidents of landfill leachate contaminating groundwater and water intake sources occur from time to time. A small amount of leachate leaking into an aquifer can pollute large areas of groundwater and surface water, making it lose its original function [6], and it is difficult to recover in the natural state.

At present, there are many studies on landfill leachate and its pollution to surface water and groundwater in surrounding rivers, but most of them focus on inorganic indicators such as nitrogen, phosphorus, and heavy metals, as well as total organic indicators such as chemical oxygen demand (COD), biochemical oxygen demand (BOD_5) and total organic carbon (TOC) content [7]. In the pollution components of landfill leachate, many refractory organic compounds have the "three-way" effect, even if the content is very low, once they enter the body, they will cause serious harm to organisms [8,9]. Therefore, the research on persistent organic pollutants in landfill leachate has become the focus of attention at home and abroad [10,11]. Because the migration and transformation of different pollutants in different environmental media are quite different, some pollutants can penetrate deep soil, especially refractory organic pollutants, and even migrate to the saturated zone of an aquifer to pollute groundwater. However, in 1997, BOD, COD, nitrogen and phosphorus in leaching liquor still exceeded the standard, and nitrogen exceeded the standard most seriously [12–14]. Therefore, in recent years, more and more scholars have paid attention to the organic pollution effects of landfill leachate on the water environmental quality of surrounding rivers [15,16]. In this paper, the impact of landfill leachate on the environmental quality of river surface water and river groundwater is studied from three aspects: the impact of landfill leachate on the environmental quality of river surface water and the impact of landfill leachate on the environmental quality of river groundwater.

2. Materials and methods

2.1. Research subjects

Two garbage transporting stations (*A* and *B*) in H city were taken as research areas respectively. The calculation units were divided into three categories [17]: fixed head unit, invalid unit and variable head unit by using Modflow (a standard visualization professional software system for three-dimensional groundwater flow and solute transport simulation evaluation). The common river *C* near the two garbage transfer stations *A* and *B* in the city is taken as the fixed head boundary and the rest as the zero flow boundary [18–20]. From March 1 to May 8, 2016, the physical and chemical properties of landfill leachate, surface water, groundwater pollutants, heavy metals in phreatic water, leachate properties of a landfill transfer station, and the discharge load of municipal river water environment by landfill transfer station were investigated and tested [21].

2.2. Indicators and methods for determination

- Sample collection. From March 1 to May 8, 2016, three rainless days were selected to collect landfill leachate from each transfer station every month, and nine times were collected. The average value of the results was obtained. In each leachate collecting tank of a refuse transfer station, leachate samples are collected with a special small bucket, the sample number of leachate raw liquid is *J*1; monitoring wells are arranged along the downstream direction of groundwater near the landfill site, and the samples of stagnant water in the upper and middle layer of groundwater and phreatic water are collected [22,23]. The monitoring well is set in the range of 300–800 m along the river groundwater flow direction (referring to the edge of the landfill site), and the contents of Cd, Pb, Fe, and Mn in the upper stagnant water samples and the diving water samples are determined. The heavy metals in the diving water samples are digested by nitric acid, and the digested solution is released into the atomic absorption spectroscopy [24]. The contents of Cd, Pb, Fe and Mn in diving water samples were determined by a spectrometer, and the surface water near the refuse transfer station was collected, numbered *J*2, two stagnant water samples in the upper layer of the river, numbered *J*3 and *J*4, and three diving water samples, numbered *J*5, *J*6, and *J*7. Table 1 shows the location and type of sampling points in the landfill of the refuse transfer station [25].
- Each sample was collected at 2,000 mL. The collected samples were put into refrigerated trucks and transported back to the laboratory for analysis [26,27].
- Measuring indicators. The monitoring items of landfill leachate are suspended solids (SS), COD, BOD_5, ammonia nitrogen, total coliform bacteria, mercury, lead, arsenic, hexavalent chromium and so on, totally 15 items [28–30]. Leachate analysis methods are shown in Table 2.

3. Results

3.1. Analysis of leachate properties

3.1.1. Analysis of pollutants in leachate and mixture

From March 1 to May 8, 2016, while investigating the water volume of each transfer station, the leachate raw liquor,

Table 1
Position and type of sampling points in the garbage dump area of a transfer station

Sample number	Distance/m	Depth/m	Water sample type
*J*1	0	0	Landfill leachate
*J*2	400	0	Surface water
*J*3	–100	<2.0	Upper water stagnation
*J*4	600	<2.0	Upper water stagnation
*J*5	500	3.0–5.0	Phreatic zone
*J*6	600	3.0–5.0	Phreatic zone
*J*7	800	3.0–5.0	Phreatic zone

Table 2
Leachate analysis method

Project	Analytical methods	Method source
PH	Water quality determination of PH value by glass electrode method	GB/T 6920-1986
Chroma	Standard colorimetry of platinum and cobalt	GB/T 11903-1989
Suspended solids	Gravimetric method	GB 11901-1989
COD	Potassium dichromate method	GB 11914-1989
BOD_5	Dilution and inoculation	GB 7488-1987
Ammonia nitrogen	Distillation and titration	GB 7478-1987
TN	Alkaline potassium persulfate	GB 11894-89
TP	Ascorbic acid reduction method	CJ/T 78-1999
Cr^{6+}	Water quality-determination of hexavalent chromium-dicarboxylic hydrazide spectrophotometric method	GB/T 7467-1987
Hg	Water quality-determination of total mercury-cold atomic absorption spectrophotometry	GB/T 7468-1987
Cu, Zn, Cd, Pb	Water quality-determination of copper, zinc, lead and cadmium-atomic absorption spectrophotometry	GB/T 7475-1987
Coliform value	Multi-tube fermentation	GB 7959-1987

Table 3
Monitoring means of contaminants in leachate and mixture

Project	Garbage transfer station *A*		Garbage transfer station *B*	
	Leachate	Mixed liquids	Leachate	Mixed liquids
PH	4.08	4.49	3.41	4.89
Chroma	320	160	200	128
ρ(SS)/(mg L^{-1})	1,880	1,675	1,232	1,187
ρ(COD)/(mg L^{-1})	11,500	9,010	60,900	54,500
ρ(BOD_5)/(mg L^{-1})	2,760	2,580	57,700	8,220
ρ(Ammonia nitrogen)/(mg L^{-1})	190.4	161.9	26.7	183.7
ρ(TN)/(mg L^{-1})	1,263	934	1,420	1,165
ρ(TP)/(mg L^{-1})	135.2	127.6	104	91.5
ρ(Cr^{6+})/(mg L^{-1})	–	–	–	–
ρ(Hg)/(mg L^{-1})	–	–	–	–
ρ(Cu)/(mg L^{-1})	–	–	0.329	–
ρ(Zn)/(mg L^{-1})	0.6	0.5	5.7	0.2
ρ(Cd)/(mg L^{-1})	0.026	0.025	0.119	0.023
ρ(Pb)/(mg L^{-1})	–	–	0.79	0.43
Escherichia coli/(number L^{-1})	$>10^7$	$>10^7$	$>10^{14}$	$>10^{11}$

and the mixed liquor after washing were collected separately to determine the concentration of pollutants. The average monitoring results were obtained. The average monitoring values of pollutants in leachate and mixed liquor were shown in Table 3.

From Table 3, it can be seen that the concentration of various monitoring indicators is very high in the mixture of leachate raw liquor and flushing water, especially in chroma, SS, COD, BOD_5, ammonia nitrogen, TN, TP, and other indicators. For H city, the COD, BOD_5, ammonia nitrogen, TN and TP of leachate and mixed wastewater from refuse transfer station exceed 225–1,500, 258–5,770, 81–133, 467–710, 229–338 times of the maximum value of GB3838–2002 surface water environmental quality standard, respectively. The mixture of landfill leachate and flushing water is discharged into urban rivers, which can increase the content of various organic pollutants in urban rivers several times. Therefore, it is particularly important to control the entry of leachate and mixed wastewater from refuse transfer stations into urban rivers.

3.1.2. Investigation on leachate discharge from various garbage transfer stations

In this paper, three types of regional refuse transfer stations are studied: compressor type, compressor type and compressor type. The compressor type is fixed in two boxes.

Therefore, compressor type and compressor type are the main refuse transfer modes of the regional refuse transfer station in this study. The amount of refuse, the amounts of flushing water used in the transfer station and the discharge of sewage in the study area for 9 d are determined. The amount and discharge method of leachate from the refuse transfer station are shown in Table 4.

Table 4 shows that the average amount of leachate produced by compression of the refuse transfer station is 8.75 t D^{-1}. After the operation of each transfer station, tap water is used to flush, flushing water and leachate are mixed, and together into the urban sewage pipe network or rain-sewage mixed connection network, discharged into the urban sewage treatment plant or urban river channel, and the sewage discharge from the municipal refuse transfer station in H city. It is 0.89%–1.25% of garbage volume, with an average of 1.07%. According to the survey, only 50% of the garbage transfer stations in H city are connected with the urban sewage network, and leachate enters the municipal sewage treatment plant for treatment; the remaining 50% of the garbage transfer stations are directly discharged into the rivers around the garbage transfer station through the rainwater pipe network or the rainwater-sewage mixed pipe network, which is similar to many other cities in the world.

3.1.3. Physicochemical property analysis and organic pollution characteristics of landfill leachate

The basic physical and chemical properties of landfill leachate in H city refuse transfer station are shown in Table 5.

From Table 5, it can be seen that the leachate quality of landfill in H city refuse transfer station has the following characteristics: CODcr and BOD_S are low, biodegradability is very poor, mainly refractory organic matter; leachate nutrition is unbalanced, alkaline, ammonia nitrogen content and chroma are high, belonging to persistent refractory biodegradable organic wastewater.

Through analysis, 137 kinds of organic matter with matching degree exceeding 60% were detected in landfill leachate, the relative content was 0.31–10.71, the average relative content was 2.22, and the highest relative content was diisooctyl phthalate. Among them, the environmental priority pollutants in China included diethylformamide toluene, phenol and three kinds of phthalic acid. Esters, aniline, naphthalene, pyrene, etc. belong to Environmental Protection Agency priority control pollutants in the United States, including phenol, phthalic acid vinegar, aniline, toluene and so on. Also, phthalate esters are important endocrine disruptors. The data show that even if the amount of phthalate esters is very small, they can cause the endocrine imbalance of organisms and various abnormal phenomena, leading to animal and human reproductive disorders, behavioral abnormalities, reproductive decline, larval death, and even population. Extinction does great harm. As an important plasticizer, phthalates may directly come from the decomposition of plastic waste.

The distribution of organic pollutants in landfill leachate of H city refuse transfer station is shown in Table 6.

Table 6 shows that leachate contains a large number of refractory organic compounds, such as phenols, amines, nitrogen-containing heterocycles and heterocyclic aromatic hydrocarbons. Among them, alcohols have the highest amount and content. Most of the detected alkanes are long-chain high-grade saturated alkanes with high molecular weight and are not easily degraded by microorganisms. From high to low, the number of different kinds of organic substances was alcohols > carboxylic acids > esters > ketones > alkenes > heterocycles > phenols > amines > aromatic hydrocarbons. It can be concluded that a large number of refractory substances in leachate are deposited at the bottom of the river course all the year-round, and then migrate slowly to the groundwater of the river course, affecting the environmental quality of the groundwater of the river course.

Table 4
Leachate production at garbage transfer station

City	Transfer station	Technological characteristics	Waste volume/ (t D^{-1})	Leachate volume/(t $D^{-1)}$	Flushing capacity/(t $D^{-1)}$	Sewage discharge/(t $D^{-1)}$	Emission direction
H	*A*	Block type	18	1.25	1.35	16	River course
	B	Compressed vehicle	20	0.5	2	25	River course

Table 5
Basic physicochemical properties of landfill leachate

Index	Chromaticity/ fold	TDS/mg L^{-1}	SS/mg L^{-1}	COD_{Cr}/ mg L^{-1}	BOD_5/ mg L^{-1}	TOC/ mg L^{-1}	Conductivity/ mS cm^{-1}	NH_3–N/ mg L^{-1}	PH
Measured value	800	8,400	96	497	45	194	9.2	1,840	8.52

Table 6
Distribution of organic pollutants in leachate

Type	Alcohols	Carboxyl group	Lipid	Ketones	Alkanes and olefins	Heterocycle	Phenols	Amine	Aromatic hydrocarbons	Total
Number	36	26	22	13	9	9	8	8	6	137

In the leachate and mixed wastewater produced by the refuse transfer station, the total coliform group content is very high, which is a potential source of pollution.

3.2. *Influences of leachate on the environmental quality of groundwater in river*

3.2.1. *Analysis of organic components in upper stagnation water*

Upper stagnant water samples *J*3 and *J*4 were collected at 100 m north and 600 m south of the landfill, respectively. The organic components of the samples are shown in Table 7.

It can be seen from Table 7 that although sample *J*3 is in the upstream direction of groundwater flow, all seven organic pollutants detected appear in landfill leachate, which indicates that these pollutants mainly come from landfill leachate. The pollution pathway may be that the pollution halo of landfill leachate has spread to the upstream of groundwater or that the pollution halo of landfill leachate has spread to the upstream of groundwater. The drifting dust or dust in the soil pollutes the nearby soil and migrates to the upper stagnant water through the leaching of the soil. Thirteen organic components were detected in *J*4, of which 10 were found in leachate. Because the sampling site is far from the landfill site, the pollutants undergo complex and intense biochemical processes in the process of migration, resulting in several substances with smaller molecular weights, such as 2,6,6-trimethyl-dicyclic (3.1.1) heptane-2,3-diol, 1,3,3-trimethyl-2-oxadiracyclic [2.2.2] octane-6-alcohol and 3-methyl-6-propyl-phenol. Because many kinds of organic pollutants are detected in the upper stagnant water samples, most of them appear in the leachate at the same time, so the pollutants in the leachate enter the upper stagnant water of the river through the migration process, and the landfill leachate will increase the pollutant content in the upper stagnant water of the river and reduce the environmental quality of the river.

Table 7
Organic pollutants in upper lagging water

Sample number	Name of organic compounds
*J*3	Diisobutyl phthalate Dibutyl phthalate (Z)-2-(9-Octadecadienyloxy)-Ethanol N-Ethyl-4-Methoxyaldehyde-ά-Phentermine 9-Octadecadienonitrile (Z)-9-Octadecane amide Diisooctyl Phthalate 2, 6, 6-Trimethyl - Second ring(3.1.1)Heptane -2, 3-Glycol 1, 3, 3-Trimethyl -2-Oxygen Heterodicyclic [2.2.2] Xin -6-Alcohol 3-Methyl-6-Propyl group-Phenol N-Methyl-4-(Methyl thio group)-2-(2, 2-Dimethylpropylene)Amino-butyramide
*J*4	Diisobutyl phthalate Dibutyl phthalate (Z)-2-(9-Octadecadienyloxy)-Ethanol N-Ethyl-4-Methoxyaldehyde-ά-Phentermine 9-Octadecadienonitrile Oleic acid amide (5ά)-Androstane -3, 12, 17-Three Ketone (5ά)-Progesterone -20-Ketone Diisooctyl phthalate

3.2.2. *Analysis of organic components in submersible water samples*

Diving samples *J*5, *J*6 and *J*7 were collected along the downstream direction of the underground river at 50, 60 and 80 m from the refuse dump area, and their organic components were shown in Table 8.

Table 8 shows that the organic components in the three aquifers are very similar. Five, seven and six kinds of organic compounds were detected in *J*5, *J*6 and *J*7 respectively. Five kinds of organic compounds were found in three phreatic water samples, and all of them could be detected in leachate. At the same time, due to the slow flow rate of groundwater, pollutants can be biologically reacted or biodegraded during the migration of the phreatic layer. The quantity and content of organic components in the phreatic layer are significantly lower than those in surface water, which indicates that the pollutants will have complex physical, chemical and biological effects in the anaerobic environment of the phreatic layer, partly because the pollutants will be trapped in the soil or soil pore water in the aerated zone. Also, with the increase of distance from landfills, the content of organic matter decreases, indicating that with the extension of migration distance, organic matter is degraded continuously. It can be concluded that all organic pollutants detected in diving water samples exist in landfill leachate, which indicates that landfill leachate brings organic pollutants into the diving layer during its migration to the diving layer, improves the content of pollutants in the diving layer, and leads to the decline of water environment quality in urban rivers.

3.2.3. *Comparison of national standards for the detection of heavy metals in groundwater samples*

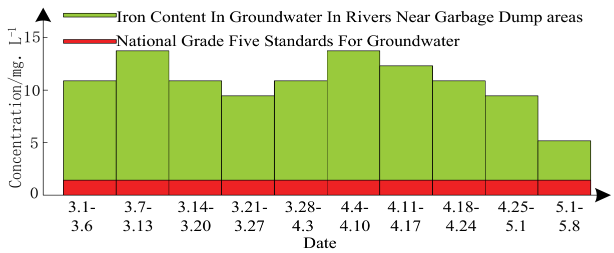
Four heavy metals, Fe, Mn, Cd and Pb, were continuously monitored in the upper and middle stagnant groundwater

Table 8
Organic pollution in submersible zone

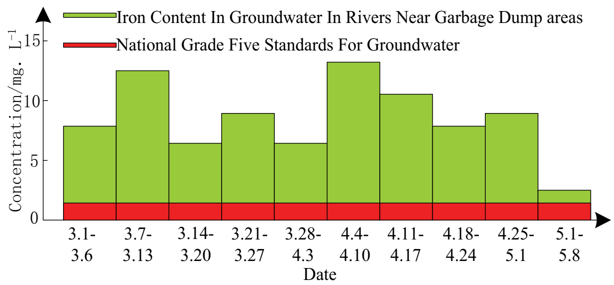
Sample number	Name of organic compounds	Relative content
J5	N-Methyl-4-(Methyl thio group), -2-(2, 2-Dimethylpropylene), Amino-butamide	0.27
	Diisobutyl phthalate	0.50
	Diisobutyl phthalate	0.85
	(Z)-2-(9-Octadecadienyloxy)-Ethanol	0.11
	Diisobutyl phthalate	0.08
J6	N-Methyl-4-(Methyl thio group), -2-(2, 2-Dimethylpropylene), Amino-butamide	0.10
	Diisobutyl phthalate	0.36
	Dibutyl phthalate	0.19
	(Z)-2-(9-Octadecadienyloxy)-Ethanol	0.08
	9-Octadecadienonitrile	0.06
	Oleic acid amide	0.10
	Diisooctyl phthalate	0.14
J7	N-Methyl-4-(Methyl thio group), -2-(2, 2-Dimethylpropylene), Amino-butamide	0.04
	Diisobutyl phthalate	0.65
	(Z)-2-(9-Octadecadienyloxy)-Ethanol	0.06
	9-Octadecadienonitrile	0.05
	Oleic acid amide	0.08
	Diisooctyl phthalate	0.26

samples and phreatic water samples of two garbage transporting stations in H city. The results show that the contents of Cd and Pb in the upper stagnant water samples and phreatic water samples are very small, and the concentration of Cd and Pb in the monitoring period does not exceed Class II of the national groundwater quality standard. However, the contents of Fe and Mn in upper stagnant water samples and phreatic water samples are very high and the pollution is serious. Fig. 1 shows the variation of Fe concentration in stagnant water samples and phreatic water samples near the landfill of the transfer station from March 1 to May 8, 2016.

The monitoring data in Fig. 1 shows that the background value of Fe concentration in stagnant water samples and phreatic water samples in the vicinity of the refuse transfer station is 0.01 mg L^{-1} before it is put into use, and the Fe content in deep groundwater is not detected. The concentration of Fe and Mn in the upper stagnant water and phreatic water of nearby rivers has increased significantly since the landfill treatment started in 2012. By 2016, the average concentration of Fe in the upper stagnant water can reach 11–10 mg L^{-1}, which is 6–7 times higher than the national groundwater grade five standard of 1.5 mg L^{-1}. The average concentration of Mn is between 0.15 and 0.8 mg L^{-1}. The average concentration of Fe in the phreatic layer can reach 8–9 mg L^{-1}, which is 5–6 times higher than the national groundwater standard of 1.5 mg/L, and the concentration of Mn is between 0.1–0.6 mg L^{-1}. The average concentration of Mn exceeds the national groundwater standard of 0.1 mg L^{-1}, although the content of Mn in the upper stagnant water and a phreatic layer is not special. High, but compared with the background value not detected, the content also increased significantly. It can be seen that groundwater in the river near the refuse transfer station has been polluted by landfill leachate, resulting in serious Fe and Mn metal pollution. It can be concluded that after a period of migration and digestion after landfill leachate is discharged into urban rivers, the heavy metal pollutants Fe and Mn produced migrate to the upper stagnant water and diving layer, which increase the content of heavy metal pollutants in groundwater and reduce the water environmental quality of rivers.



(a)



(b)

Fig. 1. Changes of Fe concentration in ground water in rivers near waste dumping areas, (a) change of Fe concentration in upper stagnation water samples and (b) changes of Fe concentration in submersible water samples.

3.3. Effect of leachate on surface water environmental quality in the river

3.3.1. Detection of surface water pollutants

Surface water samples are located at 400 m at the edge of the landfill. The results of organic matter detection in surface water near the landfill site are shown in Table 9.

A total of 13 organic compounds were detected in Table 9, with the relative content of 0.31–3.29 and the average relative content of 1.19. Among them, several substances appeared in landfill leachate, namely, N-methyl-4-(methyl thio), -2-(2,2-dimethylpropylene), amino-butylamide, (Z)-11-hexadecane-1-alcohol, diisobutyl phthalate, 3,4-dimethylbenzene. Benzophenone, dibutyl phthalate, N-ethyl-4-methoxyaldehyde-methylphenylethylamine, (Z)-9-octadecenoamide, diisooctyl phthalate vinegar, etc. These substances are likely to be directly derived from leachate leakage or the migration and diffusion of pollutants in landfill leachate. It can be seen that landfill leachate can cause certain pollution to the surface water and soil nearby through the migration and transformation of the surface. Due to the complex physical, chemical and biological effects of pollutants in the process of migration to the surrounding environment, such as filtration, adsorption, precipitation, absorption by plant roots or degradation and synthetic absorption by microorganisms, the polluted components change greatly when they are carried and transported through soil pore water. Other organic components in surface water may also come from organic matter in the soil itself or contamination of surrounding farmland. It is noteworthy that the three phthalates in surface water samples are relatively high. Also, chlorophyll (phytol) is a component of chlorophyll. The content of chlorophyll (phytol) is high in surface water, but there is no such substance in landfill leachate. It mainly comes from aquatic plants and algae. Therefore, although the leachate will pollute the surrounding rivers, two possibilities, organic matter of the soil itself and contamination of the surrounding farmland, should also be considered.

3.3.2. Sewage discharge load analysis of municipal river water environment by the refuse transfer station

According to Table 3, a large number of leachate and flushing water mixtures are directly discharged into the river, which will improve the acceptance rate of pollutants in the river and downstream water environment. Therefore, it is particularly important to analyze the discharge load of each refuse transfer station, especially for the urban river water environment. The weighted average method is used to calculate the sewage discharge load of the refuse transfer station to the urban river water environment.

$$P = \sum\left[C_i M_{i\alpha} + C_i' M_i'\left(1-\alpha\right)\right]Q \quad (1)$$

In the formula, P is the pollution load; C_i is the concentration of mixed sewage pollutants in the dry season; M_i is the proportion of leachate; α is the proportion of mixed sewage pollutants in the dry season; C_i' is the concentration of mixed sewage pollutants in the rainy season; M_i' is the amount of mixed sewage in the rainy season; Q is the proportion of sewage entering the river; the calculation results are shown in Table 10.

From Table 10, it can be seen that in small garbage transfer stations, the compressor type garbage transfer station has the highest sewage discharge load, and with the increase of the number of compartments, the sewage discharge also increases accordingly. COD load is the highest in sewage treatment plants and pollutants discharged into rivers, followed by BOD_5. A large amount of organic matter is discharged into the river, which accelerates the pollution of the river water environment. There are lakes in the lower reaches of H city. H city is the key pollution source control area in the lake basin. As the most important urban area around the lake basin, the effective control of water environmental pollution in H city will cut off the pollution source input of the lake and play an important role in the control of the lake basin. As a result, the discharge of landfill leachate has increased the discharge load of the urban river

Table 9
Testing results of organic matter in surface water

Relative content/%	Name of organic compounds	Matching degree/%
1.12	N-Methyl-4-(Methyl thio group), -2-(2,2-Dimethylpropylene), Amino-butamide	91.2
0.31	(Z)-11-Hexadecane-1-Alcohol	87.3
3.29	3, 7, 11, 15-Tetramethyl-2-Hexadecane-1-Alcohol	78.6
2.28	Diisobutyl phthalate	90.6
0.36	3-Eicosyne	69.9
0.99	Chlorophyll (Phytol)	65.4
0.46	3, 4-Dimethyl benzophenone	75.4
1.51	Dibutyl phthalate	91.8
1.72	N-Ethyl-4-Methoxyaldehyde-ά-Phentermine	87.6
1.07	3-Heptadecanol	89.3
0.51	1-Cyclohexyl dimethylsiloxane-3, 5-Dimethylbenzene	77.1
0.73	(Z)-9-Octadecane amide	85.3
1.14	Diisooctyl phthalate	90.7

Table 10
Sewage discharge load of garbage transfer station

Project	H city river	
	Garbage transfer station *A* (kg/d)	Garbage transfer station *B* (kg/d)
SS	4.61	2.99
COD	26.54	139.45
BOD_5	6.93	45.29
Ammonia nitrogen	0.46	0.50
TN	2.84	3.04
TP	0.34	0.24

water environment. At the same time, the acceptance rate of pollutants in the river and downstream water environment has also been increased. Pollutants are widely accepted and deposited at the bottom of the river, and then enter the groundwater of the river through the migration process, resulting in the decline of the overall water environment quality of the river.

4. Discussions

In this paper, the effects of landfill leachate on the quality of urban river water environment are studied from three aspects: the nature of landfill leachate from *A* and *B* garbage transfer stations in H city, the impact of landfill leachate on the surface water environment quality of rivers and the impact of landfill leachate on the groundwater environment quality of rivers. To improve the impact of landfill leachate on the water environment quality of urban rivers, some reasonable suggestions are put forward from the aspects of leachate discharge management, water resources protection and management.

4.1. Leachate discharge management

- Strengthen the management of leachate treatment plant to ensure its normal operation.
- Construct and improve the drainage pipe network after leachate treatment to ensure that it is discharged into municipal secondary sewage treatment plants or sewage treatment plants that meet the national standards.
- Expansion of existing sewage treatment plants to ensure adequate daily sewage treatment capacity.
- Establishment of emergency measures for leachate discharge: construction of emergency leachate drainage tank, temporary collection when leachate output is too large; establishment of the emergency fleet, standby emergency suction truck, in case of excess leachate for emergency use.

4.2. Water resources protection and management

Landfill leachate is one of the main factors causing the decline of water environment quality in urban rivers. To fundamentally improve the water environment quality of urban rivers, the content of polluting substances in landfill leachate can be reduced by the following means.

4.2.1. Compound treatment of physicochemical activated sludge

Physicochemical activated sludge composite technology is a common landfill leachate treatment process. When the water containing landfill leachate enters the regulating tank, activated sludge organisms at the bottom of the tank use their own inhibition to prevent the continued diffusion of contaminated substances in the solution and adsorb these substances between the cracks of sludge molecules. A proper amount of clarified lime water is added to the regulating pool, and then the mixed solution is injected into the stripping pool for a long time to be exposed to the sun. If the alkalinity of the solution in the pool is too high, a certain amount of acidic substance can be added to it to ensure that the solution is always in a medium state. Secondly, the reflux treatment of activated sludge can increase the exposure time of water resources, to fully reduce the impact of landfill leachate on hydrological resources. Activated sludge can be recycled many times in the above process, which is not only an effective reflection of the concept of sustainable development but also a way to reduce pollution control funds and improve the quality of the urban river water environment.

4.2.2. Anaerobic oxidation ditch-facultative pond treatment

The main application period of anaerobic oxidation ditch-facultative pond technology is low temperature and little rain in winter. When the temperature is too low, ammonia, nitrogen and other substances in landfill leachate cannot leave the water body through high-temperature exposure, thus making the water solution acidic. The anaerobic oxidation ditch-facultative pond technology makes full use of the instability of nitrogen element, accelerates the transformation rate of nitrogen element by adding NH_3–N solution in aqueous solution, and the whole transformation process is always in facultative anaerobic condition, which provides a strong condition for the fusion reaction of nitrogen and ammonium. With the support of anaerobic oxidation ditch-facultative pond technology, ammonia and nitrogen compounds in landfill leachate have been effectively separated, and the whole removal rate will not decrease under bad weather conditions, which provides a guarantee for better and faster reduction of the impact of landfill leachate on urban river water environment pollution.

4.2.3. Biofilm treatment

The main removal target of biofilm technology is the refractory substances in landfill leachate. Most of these substances are macromolecular impurity particles invisible to the naked eye. Traditional methods of urban river water environment treatment rely too much on physical and chemical reactions to remove these insoluble impurity particles effectively. Biofilm technology uses the idea of physics to filter the refractory and insoluble impurities in river water environment resources by continuously reducing the diameter of the membrane. This method makes the best use of the physical properties of the water solution itself, effectively filters the refractory substances in landfill leachate without biochemical reaction, and reduces the total content of all kinds of polluting substances in an urban river water environment.

5. Conclusions

This paper studies the impact of landfill leachate on the water environment quality of urban rivers from three aspects: the detection of the nature of landfill leachate, the detection of surface water after leachate discharge into rivers, and the detection of groundwater after leachate discharge into rivers.

- *Nature of landfill leachate*: the leachate is produced by the toxic substances flowing with rainwater and corrosive liquid during the process of landfill or landfill, and it contains a high concentration of inorganic and organic compounds. The concentration of COD, BOD_5, NH_3–N, TN and TP in leachate and mixed wastewater exceeded 225–1,500 times, 258–5,770 times, 81–133 times and 467–710 times of the maximum value of GB3838-2002 surface water environmental quality standard, respectively. The average amount of leachate produced by compression in H city refuses transfer station is 8.75 t D^{-1}. After the operation of each transfer station, tap water is used to flush, and the flushing water and leachate are mixed into the urban sewage network or the rain-sewage mixed pipe network is discharged into the urban river. The CODcr and BOD_5 in leachate are low, biodegradability is very poor, mainly refractory organic matter, and leachate nutrition is not balanced, alkaline, ammonia nitrogen content and chroma are very high. It belongs to persistent refractory organic wastewater. The total coliform group content in leachate and mixed wastewater produced by garbage transfer station is very high, which is potential at the source of pollution.
- *Detection of surface water in rivers*: after the leachate is discharged into rivers, the landfill leachate contains a variety of organic refractory pollutants, such as phenols, amines, nitrogen-containing heterocyclic compounds, heterocyclic aromatic hydrocarbons, and other substances. These organic pollutants can lead to different degrees of organic pollution in the upper stagnant water and diving water samples of rivers. The content of Mn also increased greatly. The pollution degree of stagnant water samples in the river course was higher than that of phreatic water samples, and the closer to landfill, the more serious the pollution was, indicating that the clay layer played a better role in preventing organic pollutants in landfill leachate. After the landfill leachate is discharged into urban rivers for some time, the heavy metal pollutants Fe and Mn are migrated to the upper stagnant water and diving layer, which increases the content of heavy metal pollutants in groundwater and reduces the water environmental quality of rivers. The emergence of various organic pollutants in groundwater shows that organic pollutants are stable in nature and have strong migration ability. It is difficult to degrade under natural conditions, which increases the pollution of landfill leachate to the river water environment.
- *River surface water monitoring*: N-methyl-4-(methylthio), -2-(2,2-dimethylpropylene), amino-butylamide, (Z)-11-hexadecane-1-alcohol, diisobutyl phthalate and other organic pollutants in leachate were detected in river surface water. With the increase in the number of garbage transfer station compartments, sewage was discharged. A large number of leachate and flushing water mixtures are directly discharged into the river, which will improve the acceptance rate of pollutants in the river and downstream water environment. Among the pollutants discharged into the river, COD load is the highest, followed by BOD_5. Organic pollutants in leachate are widely accepted in the river water environment. These organic pollutants are difficult to degrade. The deposit at the bottom of the river and migrate slowly to groundwater, which not only reduces the surface water quality of the river but also reduces the groundwater quality of the river.

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