Int. J. Nonlinear Anal. Appl. 13 (2022) 2, 1–11
ISSN: 2008-6822 (electronic)
http://dx.doi.org/10.22075/ijnaa.2023.30043.4321

Detecting and ranking environmental risks of sanitary landfilling

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(Communicated by Javad Vahidi)

Abstract

Paying attention to sanitary landfill methods and calculating their potential risks are the most logical tools to avoid waste risks. The reduction of environmental consequences caused by unprincipled landfilling, reduction of economic costs of the municipal waste management (WM) system, etc. is among the most important advantages of environmental risk assessment for sanitary landfill which is possible by detecting and evaluating the risks of sanitary landfilling. Therefore, the present research assessed the environmental risk of the sanitary landfilling of Tehran city as a case study. The research was applied-developmental in terms of purpose and detected and classified risks using interviews with experts, qualitative analysis, and previous studies. Finally, the priorities of the main risk clusters in sanitary landfilling were calculated using the analytic network process (ANP). In sanitary landfilling, chemical risks with a weight of 0.289 were ranked first, social risks with a weight of 0.259 were ranked second, and physical risks with a weight of 0.182 were ranked third. In the present study, it was sought to provide preventive and corrective measures by prioritizing the risks to minimize the risks that might occur in the Aradkuh Kahrizak landfilling site in Tehran and spread to other regions due to sanitary landfilling, thereby making it easier for managers to make decisions on waste management in the region and Tehran.

Keywords: sanitary landfill, Analytic Network Process (ANP), risk, municipal waste management
2020 MSC: 91B05

Introduction

Waste management (WM) is an accepted measure in all countries and has important consequences for human health, environmental conservation, and the economy. Sanitary landfilling is generally accepted and utilized for final waste disposal. Evaluating the effects of landfills on the environment is an important issue that has recently received great attention owing to growing environmental concerns. The increasing volume of municipal waste, increasing landfilling problems, the lack of suitable landfilling sites, and relevant environmental issues have caused the world to turn to incineration [14]. According to studies, landfill sites are places of disease-causing organisms, unpleasant and undesirable environments (contaminated view and bad odor), polluted soil, and underground and surface water. They can also cause fire, physical hazards, and poisoning. Many researchers have reported that landfill leachate can significantly affect the water quality of the regions and destroy people's lives.

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Received: November 2021 *Accepted:* February 2022

Since the risks of landfill methods such as sanitary landfilling cannot be completely eliminated, they can decrease to an acceptable level; hence, the present research sought to prioritize the risks and provide preventive and corrective measures to minimize the risks that might occur in the landfill site in Tehran and spread to other regions owing to sanitary landfilling to facilitate making decisions on waste management by managers in the region and Tehran. Paying less attention to the optimization of management systems is the most important drawback of these systems; however, providing an optimal model of the risk management program can lead to a correct and scientific management plan to achieve sustainable development goals.
The advantages of the sanitary landfill are as follows: It is the most economical method; Its initial investment is less than other landfilling methods; It does not require further steps and supplements for the final waste disposal; It does not require material separation; The landfill site can be used as green space, park, etc. Its disadvantages are as follows: Gases released from the landfill site have dangerous effects on health such as cancer and birth impairment, allergies, mental disorders, headaches, fatigue, and gastrointestinal problems as important effects of landfilling as these methods usually require relatively more transportation than other methods, and need more land than other methods.
Vyas et al. [16] conducted a study titled "Municipal solid waste management: Dynamics, risk assessment, ecological influence, advancements, constraints, and perspectives" and provided new information on ecological influence and risk assessment in municipal solid waste management and transportation. They also offered advanced trends for modifying the emerging pollutants and sources obtained from municipal solid waste.

Li et al. [9] studied "Microbial aerosol particles in four seasons of a sanitary landfill: molecular, tracking, and risk assessment approaches". They reported that landfills were prominent sources of bioaerosols for the surrounding atmosphere. Bioaerosols released from the work region and leachate treatment were the two main sources that emerged in the air around the landfill. Exposure risks were higher in summer and fall than in spring and winter.

Ghosh et al. [5] conducted a study titled "Assessment of methane emissions and energy recovery potential from the municipal solid waste landfills of Delhi, India" and utilized three main methods for estimating the increase in methane emissions (caused by improper landfilling) in Delhi-Okhla, Bhalswa, and Ghazipur landfill sites from 1984 to 2015. The effective use of landfill methane as an energy source can be a sustainable waste management option. Hereher et al. [6] evaluated the optimized sanitary landfill sites in Muscat, Oman. Their results indicated that Muscat in Oman had a rapid population growth and acceleration of solid waste production. Furthermore, the most suitable places included only 2% of the region. The best place in *Al Amarat* in Oman was chosen. Vaverková [15] investigated the "Landfill impacts on the environment". This study indicated that even if a high level of waste is disposed, reused, and recycled, some waste materials always needed to be sent for landfilling.

Njoku et al. [11] reported that 78% of the residents, who lived near the landfills, agreed on the serious air pollution, bad odor from the landfills, and diseases. Ishimura and Takeuchi [7] investigated the "spatial concentration of landfill sites in Japan". Experimental results indicate that economic factors and other waste-related facilities positively affect private landfills. Behrooznia et al. [2] investigated energy consumption, additional demand, and the main points of two scenarios of municipal waste management (MSW). Their results indicated higher total energy consumption for landfilling of composted waste than conventional landfilling. The release of environmental pollutants is inevitable in biodegradation, land biotoxins, and freshwater environmental pollution associated with compost production. According to Yang et al. [17], the characteristics of landfilled municipal solid waste have a great effect on the design, operation, and management of landfill sites, as well as town construction, slope stability, and gas/leachate well integrity. Foufou et al. [3] investigated "Water pollution diagnosis and risk assessment of Wadi Zied plain aquifer caused by the leachates of Annaba landfill (NE Algeria)". Their results indicated that leachates significantly affected the water quality of the region. Sajjadi et al. [13] presented an "environmental impact assessment of Gonabad municipal waste landfill site using Leopold Matrix". Their results indicated that the continuation of the current landfill method was rejected owing to severe environmental damage and health problems. The compost factory with the lowest negative score was the best option for the landfill site in Gonabad and was ranked first among the other four options.

Asefi et al. [1] investigated the "possible environmental hazards of the garbage dump site in Konarak crab beach in Chabahar Port". According to their results, the traditional and inefficient system of landfilling in Konarak beach near the Mangrove forests has caused many health problems in this ecosystem, and subsequently, destroyed the marine environment of Chabahar Port. Rostami et al. [12] investigated "The design, simulation, and comparison of two renewable systems using solar energy, biofuel, and incinerators to produce power and freshwater in Abu Musa Island". According to their results, both designs had the potential to fulfill a major part of the region's needs, and each of the proposed designs could be chosen according to the current priorities of the region based on strategic policies and sustainable development. Kardan Moghadam et al. [8] conducted a study titled "Using multi-criteria approaches for landfill location (Case study: Birjand city)" and assessed the location of suitable landfills in Birjand city as a strategic region. The distribution of the locations using two methods, entropy and ANP, indicated that the ANP method had a greater distance distribution than the entropy method.

Aradkuh processing and landfilling complex (Kahrizak site) is located in the south of Tehran and at the beginning of the old Tehran-Qom road. This center with an area of about 1364 ha has been the landfill site of Tehran since 1976. More than 7000 tons of waste, on average, enter this center every day. The present study aimed to detect the hazards and risks of sanitary landfilling to contribute to the presentation of the environmental risk management program.

This research creates a suitable basis for the creation of an experienced working group to make major decisions on the optimization of municipal landfill methods, planning, and creating a culture to use the private sector to participate and invest in new municipal landfill methods. The research questions are as follows:

- What is the prioritization of the risks detected in this research using the ANP method?
- What are the hazards of waste disposal using sanitary landfilling in the landfill site of Tehran on the environment of the research area?

Research methodology

The present research was applied-developmental based on the purpose and had a mixed-methods type (qualitative-quantitative) in terms of data analysis methods. The indices of sanitary landfill risks were first detected based on desk studies, and then the questionnaires were distributed, data were collected from experts, and the research entered the quantitative phase. The semi-structured interview and researcher-made questionnaire were the main data collection tools. The statistical population consisted of experimental and theoretical experts. Theoretical experts comprised university professors who were experts in sanitary landfill risks, had many books or articles in this field, had more than 10 years of teaching experience, and be faculty members of the university. Experimental experts comprised managers with more than 15 years of experience in sanitary landfill risks and postgraduate degrees in management. Non-probability purposive sampling was conducted in the qualitative phase. The sampling process continued until theoretical saturation, and finally, 11 experts participated in this stage. The data collection method was classified into desk and field methods in this study.

The expert questionnaire is based on the pairwise comparison of all elements because all the criteria have been taken into consideration in this evaluation, and the designer cannot have specific orientation in designing questions; hence, the questionnaires based on the pairwise comparison have validity [4]. The reliability of the expert questionnaire is also examined using the calculation of the inconsistency rate. The comparisons must be revised if the inconsistency of pairwise comparisons is greater than 1.0 [10]. The steps for prioritizing sanitary landfill risks using the analytic network process (ANP) are as follows:

1- Prioritizing the main risks based on the purpose through pairwise comparison

2- Detecting the internal relationships between the main risks using the DEMATEL method

3- Prioritizing each sub-criterion in its relevant cluster using the pairwise comparison

4- Calculating the initial, weighted, and limit supermatrices

The analytic network process (ANP) and *SuperDecisions* software were utilized to rank sanitary landfill risks. In the first step, the main decision criteria were detected, and thus the research literature was reviewed.

Findings

In terms of gender, demographic characteristics included 3 females and 8 males. Two experts were only university professors (theoretical experts) and 9 were university professors and also industry activists (experimental and theoretical). Furthermore, 3 experts had 15 years or less of work experience and 8 had more than 15 years of work experience. In terms of education level, 3 had master's degrees and the rest 8 had Ph.D. Table 1 examines 6 main risks and 39 sub-criteria.

The experts' opinions were gathered using the geometric mean technique which calculated the final weights of the criteria (Table 2).

The inconsistency rate of the comparisons is equal to 0.060 which is lower than 0.1; hence, the comparisons can be trusted. Table 3 presents the direct-influence matrix of sanitary landfill risks with the arithmetic mean of experts' views.

Table 1: Sanitary landfill risks according to desk studies

Sanitary landfill risks	**Sub-risks**	**Symbol**
Chemical risks (RL1)	Soil pollution	RL11
	Groundwater pollution	RL12
	Surface water pollution	RL13
	Air pollution	RL14
Physical risks (RL2)	The risk of transfer of suspended particles and pollutants by wind	RL21
	Reducing plant biodiversity and changing native species	RL22
	Soil erodibility	RL23
	Migration of animals and birds from the region	RL24
	Noise	RL25
	leachate seepage	RL26
	Influx of invasive species	RL27
Environmental risks (RL3)	Earthquake	RL31
	Landslide	RL32
	Flood	RL33
	Explosion	RL34
	Fire	RL35
	Storm	RL36
Economic risks (RL4)	Proximity to industrial areas	RL41
	High cost of human resources	RL42
	Energy resources	RL43
	Reduction in the price of land and real estate in the region	RL44
	High tax burden	RL45
	High cost of landfill equipment, controllers, and drainage	RL46
	Transportation	RL47
Social risks (RL5)	Proximity to power transmission lines	RL51
	Proximity to side roads	RL52
	Odor	RL53
	Proximity to main roads	RL54
	Traffic	RL55
	Proximity to the airport	RL56
	Land use change	RL57
	Satisfaction of local communities	RL58
Cultural risks (RL6)	Proximity to tourist and entertainment areas	RL61
	Migration	RL62
	Proximity to protected areas	RL63
	Education	RL64
	Destruction of monuments	RL65
	Proximity to urban and rural areas	RL66
	Public participation	RL67

Source: author

Table 2: Pairwise comparison matrix of the main risks of sanitary landfill (Source: author)

	RL1	RL2	RL3	RL4	RL5	RL6	Geometric mean	Eigenvector
RL1	1	1.475	3.769	3.067	1.691	2.503	2.041	0.289
RL2	0.678	1	3.012	1.346	0.653	2.492	1.284	0.182
RL3	0.265	0.332	1	0.536	0.270	0.660	0.451	0.064
RL4	0.326	0.743	1.867	1	0.537	0.685	0.742	0.105
RL5	0.591	3.707	3.707	1.861	1	2.503	1.832	0.259
RL6	0.399	0.401	1.514	1.459	0.399	1	0.722	0.102

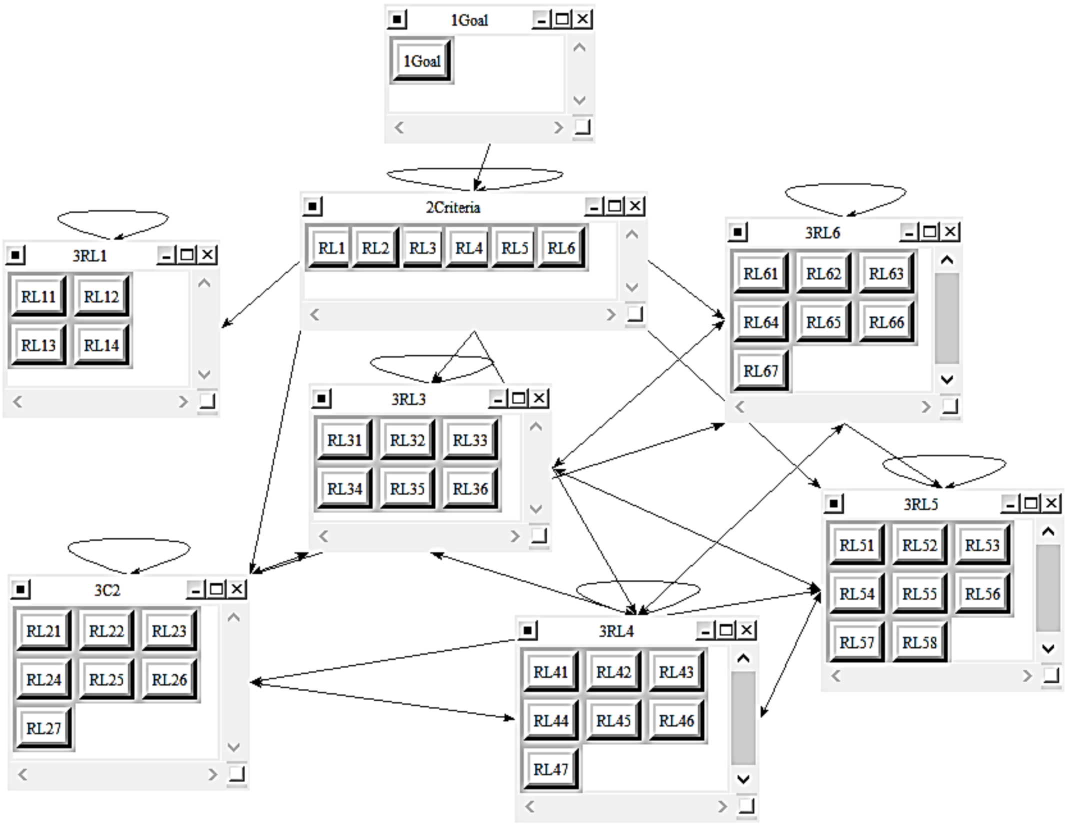

Figure 1: A network model of sanitary landfill risks (Source: author)

Table 3: Direct-influence matrix of sanitary landfill risks (Source: author)

X	RL1	RL2	RL3	RL4	RL5	RL6
Chemical risks (RL1)	0.000	3.182	2.727	2.636	3.364	1.636
Physical Risks (RL2)	3.091	0.000	3.364	2.818	3.273	1.455
Environmental risks (RL3)	2.182	2.455	0.000	1.727	2.273	1.545
Economic risks (RL4)	1.909	1.909	1.727	0.000	3.000	1.818
Social risks (RL5)	3.182	3.000	2.455	3.182	0.000	2.455
Cultural risks (RL6)	1.636	1.455	3.000	2.091	2.909	0.000

To normalize the direct-influence matrix (N), the sum of all rows and columns was calculated and the largest value was measured as 14.82. All entries of the direct-influence matrix were divided by this number to make the matrix normal (Table 4).

$$k = \max\left\{\max\sum_{j=1}^{n} x_{ij},\ \sum_{i=1}^{n} x_{ij},\right\} = 14.82$$

$$N = \frac{1}{14.82} * X$$

Table 4: Normalized direct-influence matrix of sanitary landfill risks (Source: author)

N	RL1	RL2	RL3	RL4	RL5	RL6
Chemical risks (RL1)	0.000	0.215	0.184	0.178	0.227	0.110
Physical Risks (RL2)	0.209	0.000	0.227	0.190	0.221	0.098
Environmental risks (RL3)	0.147	0.166	0.000	0.117	0.153	0.104
Economic risks (RL4)	0.129	0.129	0.117	0.000	0.202	0.123
Social risks (RL5)	0.215	0.202	0.166	0.215	0.000	0.166
Cultural risks (RL6)	0.110	0.098	0.202	0.141	0.196	0.000

The following equation was used to measure the total influence matrix (T):

$$T = N \times (I - N)^{-1}$$

Table 5 presents the total influence matrix.

Table 5: Total influence matrix of sanitary landfill risks (Source: author)

T	RL1	RL2	RL3	RL4	RL5	RL6
Chemical risks (RL1)	0.912	1.096	1.078	1.090	1.225	0.797
Physical Risks (RL2)	1.111	0.935	1.130	1.119	1.243	0.803
Environmental risks (RL3)	0.843	0.858	0.716	0.837	0.942	0.639
Economic risks (RL4)	0.836	0.837	0.830	0.737	0.987	0.662
Social risks (RL5)	1.119	1.112	1.090	1.144	1.064	0.860
Cultural risks (RL6)	0.744	0.736	0.767	0.786	0.859	0.491

The threshold value must be calculated to determine the network relationship map (NRM). The threshold value was obtained equal to 0.816 in the present study; hence, the pattern of significant relationships is as follows. (Table 6)

Table 6: Pattern of significant relationships of sanitary landfill risks (Source: author)

T	RL1	RL2	RL3	RL4	RL5	RL6
Chemical risks (RL1)	×	1.09947	0.967	0.936	1.083	×
Physical Risks (RL2)	0.957	×	1.014	0.961	1.097	×
Environmental risks (RL3)	×	×	×	×	0.833	×
Economic risks (RL4)	×	×	×	×	0.879	×
Social risks (RL5)	0.970	0.962	0.983	0.990	0.930	×
Cultural risks (RL6)	×	×	0.836	×	0.899	×

The values of the total influence matrix can be utilized to determine the affectability and effectiveness of the variables. Furthermore, the rates of interactions and the cause-effect status of the elements can be examined (Table 7).

Social risks (RL5) have the highest effectiveness, highest affectability, and highest interaction. In this model, physical, chemical, and cultural risks are causal and other risks are under effects.

In the third step, the ANP technique is used to provide a pairwise comparison of the sub-criteria of each criterion. Table 8 presents the pairwise comparison matrix of chemical risks.

Table 7: Affectability and effectiveness of sanitary landfill risks (Source: author)

Sanitary landfill risks	D	R	$D+R$	$D-R$
Chemical risks (RL1)	5.385	4.874	10.258	0.511
Physical Risks (RL2)	5.502	4.881	10.383	0.620
Environmental risks (RL3)	4.207	5.183	9.390	-0.977
Economic risks (RL4)	4.266	4.993	9.259	-0.727
Social risks (RL5)	5.580	5.7200	11.301	-0.140
Cultural risks (RL6)	4.432	3.719	8.152	0.713

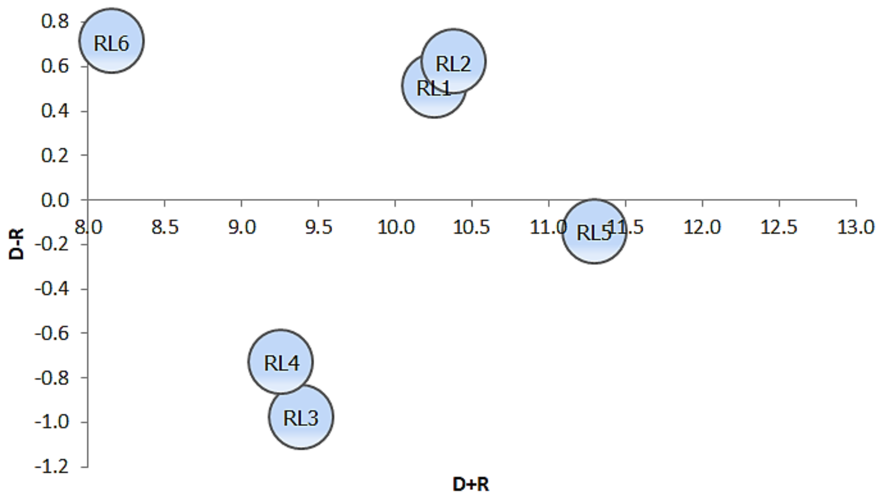

Figure 2: Cartesian coordinate diagram of sanitary landfill risks (Source: author)

Table 8: Pairwise comparison matrix of chemical risks (Source: author)

	RL11	RL12	RL13	RL14	Geometric mean	Eigenvector
RL11	1	0.700	1.271	0.722	0.895	0.205
RL12	1.429	1	3.705	2.436	1.895	0.435
RL13	0.787	0.270	1	0.722	0.626	0.144
RL14	1.385	0.411	1.385	1	0.942	0.216

The inconsistency rate of the comparisons is equal to 0.031 Table 3 presents the pairwise comparison matrix of physical risks.

Table 9: Pairwise comparison matrix of physical risks (Source: author)

	RL21	RL22	RL23	RL24	RL25	RL26	RL27	Geometric mean	Eigenvector
RL21	1	0.804	0.616	0.414	3.020	0.207	1.121	0.758	0.088
RL22	1.244	1	1.947	0.291	1.573	0.204	1.739	0.876	0.101
RL23	1.622	0.514	1	0.703	4.509	0.212	0.622	0.860	0.099
RL24	2.413	3.436	1.422	1	4.629	0.368	0.927	1.519	0.176
RL25	0.331	0.222	0.222	0.216	1	0.140	0.381	0.294	0.034
RL26	4.831	4.890	4.713	2.715	7.137	1	2.101	3.329	0.385
RL27	0.892	0.575	1.607	1.079	2.625	0.476	1	1.015	0.117

The inconsistency rate is equal to 0.034. Table 10 presents the pairwise comparison matrix of environmental risks.

The inconsistency rate is equal to 0.016. Table 11 presents the pairwise comparison matrix of economic risks.

The inconsistency rate is equal to 0.068. Table 12 presents the pairwise comparison matrix of social risks.

The inconsistency rate is equal to 0.066. Table 13 presents the pairwise comparison matrix of cultural risks.

Table 10: Pairwise comparison matrix of environmental risks (Source: author)

	RL31	RL32	RL33	RL34	RL35	RL36	Geometric mean	Eigenvector
RL31	1	0.885	0.568	2.002	0.450	0.449	0.767	0.111
RL32	1.130	1	0.389	3.575	0.377	0.377	0.779	0.113
RL33	1.761	2.570	1	3.867	0.460	0.656	1.319	0.191
RL34	0.499	0.280	0.259	1	0.236	0.258	0.361	0.052
RL35	2.223	2.173	2.173	4.237	1	1.154	1.928	0.279
RL36	2.226	2.654	1.526	3.873	0.866	1	1.765	0.255

Table 11: Pairwise comparison matrix of economic risks (Source: author)

	RL41	RL42	RL43	RL44	RL45	RL46	RL47	Geometric mean	Eigenvector
RL41	1	0.874	0.735	0.872	2.784	0.828	0.556	0.954	0.112
RL42	1.144	1	2.752	0.503	4.580	0.211	1.025	1.067	0.125
RL43	1.360	0.363	1	0.671	3.114	0.142	0.471	0.682	0.080
RL44	1.147	1.989	1.491	1	3.943	0.427	1.184	1.315	0.154
RL45	0.59	0.321	0.321	0.254	1	0.139	0.226	0.313	0.037
RL46	1.208	4.729	7.061	2.343	7.214	1	2.654	2.920	0.343
RL47	1.799	0.976	2.124	0.844	4.416	0.377	1	1.267	0.149

Table 12: Pairwise comparison matrix of social risks (Source: author)

	RL51	RL52	RL53	RL54	RL55	RL56	RL57	RL58	Geometric mean	Eigenvector
RL51	1	0.304	0.175	0.438	0.223	0.282	0.169	0.390	0.315	0.034
RL52	3.291	1	0.315	0.551	0.237	0.806	0.209	0.261	0.527	0.056
RL53	5.713	3.172	1	0.800	1.601	1.780	0.671	3.819	1.791	0.191
RL54	2.282	1.815	1.249	1	1.023	0.763	0.265	1.000	1.008	0.107
RL55	4.483	0.624	0.624	0.977	1	0.977	0.212	2.127	0.965	0.103
RL56	3.545	1.240	0.562	1.310	1.023	1	0.671	0.916	1.093	0.116
RL57	5.908	4.780	1.491	3.780	4.722	1.491	1	1.512	2.533	0.270
RL58	2.566	3.826	1.000	1.000	0.470	1.092	0.661	1	1.162	0.124

Table 13: Pairwise comparison matrix of cultural risks (Source: author)

	RL61	RL62	RL63	RL64	RL65	RL66	RL67	Geometric mean	Eigenvector
RL61	1	1.026	0.548	0.282	0.956	0.148	0.703	0.553	0.056
RL62	0.975	1	2.798	0.355	3.144	0.173	0.488	0.824	0.084
RL63	1.826	0.357	1	0.194	1.521	0.143	0.568	0.552	0.056
RL64	3.543	2.815	5.157	1	3.264	0.211	0.724	1.590	0.162
RL65	1.046	0.657	0.657	0.306	1	0.145	0.154	0.438	0.045
RL66	6.756	5.775	6.986	4.729	6.902	1	3.914	4.455	0.453
RL67	1.422	2.050	1.761	1.382	6.502	0.255	1	1.422	0.145

The inconsistency rate is equal to 0.084. To determine the final weight, the output of the comparison of the main risks based on the purpose and internal relationships among the criteria is presented in a supermatrix.

The priority of each sanitary landfill risk was determined on this basis. Therefore, groundwater pollution was the most important issue. Leachate seepage was ranked second, and proximity to urban and rural areas was the third priority.

Discussion and conclusion

Industrial waste disposal at the landfilling and processing site in the metropolis of Tehran for more than several decades with the need for transportation of several thousand tons of waste daily has led to environmental, social, and other problems. These issues along with the capacity of these centers made us study and evaluate environmental risks.

Table 14: Final prioritization of sanitary landfill risks (Source: author)

Sanitary landfill risks	Total weight	Normal weight
Soil pollution (RL11)	0.0187	0.0375
Groundwater pollution (RL12)	0.0398	0.0796
Surface water pollution (RL13)	0.0132	0.0263
Air pollution (RL14)	0.0198	0.0395
The risk of transfer of suspended particles and pollutants by wind (RL21)	0.0082	0.0164
Reducing plant biodiversity and changing native species (RL22)	0.0094	0.0188
Soil erodibility (RL23)	0.0092	0.0185
Migration of animals and birds from the region (RL24)	0.0164	0.0328
Noise (RL25)	0.0032	0.0063
leachate seepage (RL26)	0.0359	0.0718
Influx of invasive species (RL27)	0.0109	0.0218
Earthquake (RL31)	0.008	0.016
Landslide (RL32)	0.0081	0.0163
Flood (RL33)	0.0138	0.0275
Explosion (RL34)	0.0037	0.0075
Fire (RL35)	0.0201	0.0402
Storm (RL36)	0.0184	0.0367
Proximity to industrial areas (RL41)	0.0082	0.0164
High cost of human resources (RL42)	0.0091	0.0183
Energy resources (RL43)	0.0058	0.0117
Reduction in the price of land and real estate in the region (RL44)	0.0112	0.0225
High tax burden (RL45)	0.0027	0.0054
High cost of landfill equipment, controllers, and drainage (RL46)	0.025	0.0501
Transportation (RL47)	0.0109	0.0218
Proximity to power transmission lines (RL51)	0.0032	0.0065
Proximity to side roads (RL52)	0.0053	0.0107
Odor (RL53)	0.0182	0.063
Proximity to main roads (RL54)	0.0102	0.0204
Traffic (RL551)	0.0098	0.0196
Proximity to the airport (RL56)	0.011	0.0221
Land use change (RL57)	0.0257	0.0514
Satisfaction of local communities (RL58)	0.0118	0.0236
Proximity to tourist and entertainment areas (RL61)	0.0042	0.0084
Migration (RL62)	0.0063	0.0126
Proximity to protected areas (RL63)	0.0042	0.0084
Education (RL64)	0.0121	0.0243
Destruction of monuments (RL65)	0.0034	0.0067
Proximity to urban and rural areas (RL66)	0.0339	0.0678
Public participation (RL67)	0.0109	0.0217

- The prioritization of the main risks was as follows: Chemical risks with a weight of 0.289 in priority 1, social risks with a weight of 0.259 in priority 2, physical risks with a weight of 0.182 in priority 3, economic risks with a weight of 0.105 in priority 4, cultural risks with a weight of 0.102 in priority 5, and environmental risks with a weight of 0.064 in priority 6.

- The prioritization of environmental risks was as follows: 1- Chemical risks, including groundwater pollution risk with a weight of 0.435, air pollution risk with a weight of 0.216, soil pollution risk with a weight of 0.205, and surface water pollution risk with a weight of 0.144 respectively. 2- Physical risks, including the risk of leachate seepage with a weight of 0.385, the risk of migration of animals and birds in the region with a weight of 0.176, the risk of influx of invasive species with a weight of 0.117, the risk of reducing the biodiversity of plants and changing native species with a weight of 0.101, the risk of soil erodibility with a weight of 0.099, the risk of transfer of suspended particles and pollutants with the wind with a weight of 0.088, and the risk of noise pollution with a weight of 0.034.

- The prioritization of environmental risks was as follows: The fire risk with a weight of 0.279, storm risk with a weight of 0.255, flood risk with a weight of 0.191, landslide risk with a weight of 0.113, and earthquake risk with a weight of 0.111.
- The prioritization of economic risks was as follows: the risk of the high cost of landfill equipment, controllers, and drainage with a weight of 0.343, the risk of reduction of the price of land and real estate in the region with a weight of 0.154, the risk of transportation with a weight of 0.149, the risk of the high cost of providing human resources with a weight 0.125, the risk of proximity to industrial areas with a weight of 0.112, the risk of energy resources with a weight of 0.08, and the risk of a high tax burden with a weight of 0.037.
- The prioritization of social risks was as follows: The land use change risk with a weight of 0.27, the odor risk with a weight of 0.191, the risk of l satisfaction of local communities with a weight of 0.124, the risk of proximity to the airport with a weight of 0.116, risk of proximity to main roads with a weight of 0.107, traffic risk with a weight of 0.103, risk of proximity to side roads with a weight of 0.056, and risk of proximity to power transmission lines with a weight of 0.034.
- The prioritization of cultural risks was as follows: The risk of proximity to urban and rural areas with a weight of 0.453, the risk of education with a weight of 0.162, the risk of public participation with a weight of 0.145, the risk of immigration with a weight of 0.084, the risk of proximity to tourist and recreational areas with a weight of 0.056, the risk of proximity to protected areas with a weight of 0.056, and risk of destruction of monuments with a weight of 0.045.

The following corrective measures are suggested according to the above-mentioned prioritization:

1. Locating: moving to a more suitable location
2. Equipment and continuous monitoring of the compost unit: Some factors, which can be monitored, should be controlled by creating a suitable context and equipment.
3. Automatic facilities for separation at origin and destination such as separating metals with magnets
4. Planting suitable plants for the landfill site: Suitable plants can reduce pollution by increasing the treatment capacity.
5. Development of the treatment device according to modern technologies: Since the landfill leachate has a significant pollution load, the treatment device with chemical, physical, and biological leachate treatment capacity can reduce this pollution load at the source.
6. Changes in land use in the surrounding areas decrease the value of properties.
7. Continuous monitoring of Landfill gas (LFG) operation system, appropriate daily waste coverage, and odor dilution materials.
8. Effective use of landfill methane as an energy source can be a sustainable waste management option.
9. Creating stations outside the center to reduce the volume of waste before entering the site.
10. Using carbon nanotubes to reduce the rate of pollution before the leachate enters the treatment site.

The results of the present research can be used by the municipality, the waste management organization, the Ministry of Industry, Mine, and Trade, the Ministry of Cooperatives, Labor, and Social Welfare, the Environmental Protection Agency, university researchers, and urban management research institute researchers. Future research is suggested to take corrective measures for each prioritized risk in this study, and then recalculate the severity of the risk, the probability of occurrence, and the detectable potential, and finally, analyze the effectiveness of each corrective measure.

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