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Screening of Organic Polluted Soil Remediation Technology in a Coking Plant Site in Qingdao

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Abstract

Taking a coking plant site in Qingdao as a research object, a scientific method is used to research and screen the remediation technology applicable to the organic contaminated soil in the site, which provides a reference for the screening of similar contaminated sites and the engineering application. Based on the characteristics of contaminated sites and the characteristics of remediation technology, the analytic hierarchy process (AHP) was used to qualitatively analyze and quantitatively calculate the three types of contaminated site remediation programs. AHP can simplify complex problems into hierarchical models, effectively solve multi-objective decision-making problems, and scientifically screen out the most suitable remediation schemes for contaminated sites.

Keywords

Contaminated Site, Remediation Technology Screening, Analytic Hierarchy Process, Multi-objective decision problem.

1. Introduction

In evaluating and screening contaminated soil remediation technology, many factors need to be considered.Environmental factors, economic conditions,technical conditions, and social conditions and other factors affect each other to some extent,which is a major problem in selecting the best remediation technology.It is of great significance to use scientific methods to screen out repair techniques that are suitable for the technology, have the best repair effect, and are economical and environmentally friendly.Brian J. Grelk et al. specified the"Nine Principles"in the US Super Fund Law, proposed 21 evaluation indicators, and listed relevant evaluation methods[1]. Hayes et al. calculated and determined the weight of each evaluation index according to the process stipulated in the US Super Fund Law,based on the Bradley-Terry model,and used the multi-parameter utility function to determine the optimal repair technology[2].Compar-

ed with foreign researches on screening of contaminated soil remediation technology, China started late.In 2008,Luo Chengzhong referred to the basic method of super-fund contaminated site treatment and repair technology selection, and proposed a POPs contaminated site repair technology screening route in China[3]. The earliest use of analytic hierarchy process to screen out suitable POPs contaminated site repair technology. Xiao Yening further considered the three indicators, including technical indicators, environmental indicators, and economic indicators, and compared the four types of restoration solutions that were initially selected for the site environment[4]. Best repair techniques. Pan Wen used the analytic hierarchy process to comprehensively analyze various factors to prioritize 8 kinds of remediation technologies suitable for a heavy metal contaminated site and screen out the best remediation methods[5].Luo Yun proposed a model and evaluation index system for contaminated site remediation technology,and applied the constructed contaminated site remediation technology evaluation method to chromium slag contaminated sites[6]. Wang Xinxiu combined the

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evaluation index with the GIS system, introduced the ArcEngine-based contaminated site remediation technology screening platform, combined with the characteristics and requirements of the contaminated site,made a decision in the remediation technology screening library,and selected the most suitable remediation technology[7].

This study combines engineering cases and uses an analytical hierarchy process (AHP) to construct a screening index system for remediation technologies for contaminated sites. The AHP was used to determine the pollution site remediation technology to screen the weights of various indicators, and the pollution site remediation technology was ranked to determine the best solution for the pollution site remediation technology.

2. Overview of contaminated sites

The land used for a construction project in Qingdao was originally a coking plant site. Due to factors such as the production process of the coking plant, the soil in the site was contaminated to a certain extent.According to the requirements of the State Environmental Protection Administration and the Qingdao Environmental Protection Bureau, conduct site environmental surveys on polluted sites.The preliminary site investigation,detailed investigation and risk assessment confirmed that the soil organic pollution characteristic factors of the contaminated site are mainly volatile organic compounds(1,2,3-trichloropropane,Naphthalene) and semi-volatile organic compoun-ds (Benzoapyrene, Benzo a Anthracene,Benzo(b)fluoranthene,Indeno(1,2,3-cd) fluore-ne), Dibenzo (a,h) anthracene).

3. Screening of remediation technologies for contaminated sites

3.1 Remediation technology screening process

The screening of contaminated sites is a multi-objective decision problem. There are many types of remediation technologies, complex principles, many factors such as pollutant characteristics, technical feasibility, economic requirements and social requirements all have an important influence on the selection of remediation technologies. The screening process of soil remediation technology for contaminated sites in this article is: ① Under the premise of clear selection of the most suitable for site contaminated soil remediation technology, the final selection of remediation technology should be used to determine the decision plan; ② combining technical characteristics and project requirements And other factors to determine the screening evaluation index; ③ use AHP to calculate the weight of each evaluation index; ④ determine the optimal solution based on the repair technology score and index weight

3.2 Method for determining weights of screening indicators

AHP is a method of qualitative and quantitative analysis of evaluation indicators [8].It simplifies the complex multi-objective decision problem into a hierarchical model for hierarchical total ranking. Specific steps are as follows:

(1) Constructing a judgment matrix between the target layer and the target evaluation layer

Compare and judge each index. Make a judgment on the relative importance of each evaluation index, and express the judgment result in a quantitative form, that is, quantify the importance of each index. Compared with each other, the importance of each evaluation index is expressed on a scale of 1-9[9],As shown in table 1

Table 1 Quantitative judgment table of relative importance of indicators

Amount	Meaning
1	Both indicators are equally important
3	The former is slightly more important / advantageous than the latter

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5	The former is more important / advantageous than the latter
7	The former is more important / advantageous than the latter
9	The former is definitely more important / advantageous than the latter
2,4,6,8	Represent the median of the above judgment

Note: The latter index is judged by the inverse of the corresponding value in the table.

According to Table 2,a decision matrix suitable for contaminated site remediation technology is established,and after normalization processing, the vectors are added by rows,and the vectors are normalized to obtain the target layer weight vector.

(2)Construct a judgment matrix of the evaluation index corresponding to each target evaluation layer.

Repeat the above steps to calculate the weight of the evaluation index corresponding to each target evaluation layer and perform normalization processing. Calculate the weighted weight of each evaluation index.

(3) Consistency inspection

Check the consistency of each judgment matrix. Random consistency ratio $CR = \frac{CI}{RI}$, when$CR < 0.1$,it is considered that the hierarchical single-ranking result has satisfactory consistency.Among them, the consistency index $CI = \frac{\lambda_{max}-n}{n-1}$,$\lambda_{max}$ is the maximum characteristic root of the judgment matrix.The values can be found in the research results of Professor Saaty[10].

3.3 Evaluation Index System of Remediation Technology

Based on the requirements of current national laws and regulations and the needs of social development,this study takes economic indicators,technical indicators, environmental indicators, and social indicators as the target evaluation layer in combination with China's economic strength, technological level, and project characteristics.The cement cellar co-processing technology and chemical oxidation technology are used as the scheme layer, and the evaluation indicators are operability, repair time,capital construction costs, operating costs,later costs, health risks, residual risks,long-term risks,public acceptance, and management acceptance.

4. Sorting of repair techniques

4.1 Determination of screening index weights

Establish a judgment matrix (A-B) for the target layer A and the target evaluation layer B and calculate their relative weights. The judgment matrix is shown in Table 2.

Table 2 Judgment matrix (A-B)

Factors	Technology	Economic	Environment	Society
Technology	1	1/2	1/3	1/3
Economic	2	1	1/2	1/2
Environment	3	2	1	1
Society	3	2	1	1

Weight calculation is available. The weights of technical indicators, economic indicators, environmental indicators, and social indicators are 0.1093,0.1892,0.3507, and 0.3507, λ_{max}=4.01, $CR = 0.0039 < 0.1$.Thehierarchical single ordering has satisfactory consistency.

See Table 3 for the technical index corresponding weight judgment matrix.

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Table 3 Weight judgment matrix corresponding to technical indicators

Factors	Operability	Repair Time
Operability	1	1/2
Repair Time	2	1

Weight calculations are available, and the corresponding weights for operability and repair time are 0.3333 and 0.6667, $\lambda_{\max}$ =2.00, $CR = 0 < 0.1$ .Hierarchical single ordering has satisfactory consistency.

See Table 4 for the corresponding weight judgment matrix of economic indicators.

Table 4 Weight judgment matrix corresponding to economic indicators

Factors	Capital construction cost	Operating expenses	Late expenses
Capital construction cost	1	1/2	3
Operating expenses	2	1	4
Late expenses	3	4	1

The calculation of weights is available,and the corresponding weights for capital construction costs, operating costs, and later costs are 0.3202, 0.5571,and 0.1226, $\lambda_{\max}$ =3.02， $CR = 0.017 < 0.1$.Single-level hierarchy has satisfactory consistency.

See Table 5 for the corresponding weight judgment matrix of environmental indicators.

Table 5 Judgment matrix for corresponding weights of environmental indicators

Factors	Residual effects	Long-term effects	Health effects
Residual effects	1	1	1
Long-term effects	1	1	1
Health effects	1	1	1

Weight calculation is available, and the corresponding weights of residual risk, long-term effect, and health risk are 0.3333, 0.3333, and 0.3333, $\lambda_{\max}$=3.00， $CR = 0 < 0.1$.Single-level hierarchy has satisfactory consistency.

See Table 6 for the social index corresponding weight judgment matrix.

Table 6 Judgment matrix of corresponding weights of social indicators

Factors	Management acceptance	Public acceptance
Management acceptance	1	1
Public acceptance	1	1

Weight calculation is available. The corresponding weights for management acceptance and public acceptance are 0.5 and 0.5,$\lambda_{\max}$=,2.00， $CR = 0 < 0.1$,and the hierarchical single ordering has satisfactory consistency.

Normalize the corresponding weights of each indicator to determine the normalized weights of health risks, residual risks, long-term effects, public acceptance, management acceptance, repair time, operability, capital construction costs, later costs, and operating costs are 0.1169, 0.1169, 0.1169, 0.1754, 0.1754, 0.1754, 0.1754, 0.0729, 0.0364, 0.0606, 0.0232,and0.1054.

4.2 Hierarchical total ordering

This study refers to"Guidelines for Screening Remediation Techniques for Contaminated Sites", "Guidelines for the Preparation of Remediation Techniques for Contaminated Sites", "Catalogue of

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Remediation Techniques for Contaminated Sites (First Batch)" and relevant literature and materials. Scoring assignment.The evaluation index of in situ repair technology is 3, 5, 1, 4, 3, 4, 4, 4, 4, 4, and the evaluation index of cement pit co-processing technology is4,4,2,2,3,4,4,2,4,4,each evaluation index of the chemical oxidation technology scores 3,5,1,3,3,3,4,3,4,4.According to the calculation of the index scores and their weights.It can be known that the in-situ ex-situ thermal desorption technology is the best solution suitable for the organic contaminated soil restoration technology of the project site.

5. Conclusion

(1) As the site construction project is a municipal key livelihood project, the restoration and treatment of polluted soil is highly valued by the local government and the public, and the distance to the surrounding residential quarters and commercial areas is relatively close. The impact of the restoration plan on the environment is particularly critical. Based on this, combined with relevant data, the analytic hierarchy process was used to construct a hierarchical structure model of the screening index for contaminated soil remediation technology. The corresponding judgment matrix for the screening index was constructed, and the total ranking of the screening index weights was calculated.

(2) Based on the total ranking of the screening index weights obtained from the analytic hierarchy process and the scores of each repair technology, calculate and determine the in situ thermal desorption technology as the most suitable repair technology for the organic contaminated soil of the project site, which is consistent with the actual application of the repair technology.

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