Study on Evaluation System of Green Landfill Based on Life Cycle —— Illustrated by the Case of Hangzhou Tianziling Landfill

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Abstract. Recently, the environmental problems of Hangzhou Tianziling Landfill have brought great troubles to the lives of nearby residents. Landfill is the main method of garbage disposal. The requirement of green environment protection about landfill is becoming higher and higher, and the way in which the important indicators affects the environmental of landfill has also followed by lots of interest. In this paper, on the basis of the whole life cycle evaluation index system of landfill, the evaluation index of green landfill is increased, and then the evaluation index system of green landfill based on the whole life cycle is constructed by using hierarchical analysis method. Using Hangzhou Tianziling Landfill as a case to establish the practical model; establishing the hierarchical index weight and calculating it. Comparing the weight of each index shows that the proportion of odor concentration in environmental protection index is largest, and finally the comprehensive evaluation score of Hangzhou Tianziling Landfill based on life cycle is obtained.

1. Introduction
In recent years, landfills have gradually become the main means of municipal waste disposal. The quality of landfills is very important for the control of waste pollution and the mitigation of waste hazards. However, with the rise of landfills in the urban area, the problems exposed by landfills are gradually increasing. Environmental damage caused by landfills such as soil acidification, water pollution and air pollution has become a major problem plaguing urban residents. The deterioration of such problems is likely to lead to extremely adverse social effects.

Take Hangzhou Tianziling Landfill as an example. This landfill is the first municipal waste landfill in China. It was put into operation in April 1991 and its service period expired in 2004. Subsequently, the expansion project of the landfill began in 2003 and was completed in 2006. The design service life is 24.5 years. Today, the amount of garbage can reach 1940-4000 tons per day. The combination of vertical seepage control and horizontal seepage control is used for seepage control of leachate. However, in recent years, the problem of odor pollution in the landfill has become more and more serious, which not only poses a great threat to the health of residents, but also has a great impact on the urban ecological environment. With the increasing number of complaints from Hangzhou residents about Tianziling Landfill, more attention has been paid to the problems of landfill.
In the field of landfill research, domestic and foreign scholars have carried out many related studies on waste disposal: Obersteiner Gudrun (2007) and others have introduced life cycle inventory (LCI) in the study of waste landfill and modelled the landfill in life-cycle assessment (LCA). Xu Ya (2016) and others have combined the construction of EMAMLL model and aging model to carry out the study on safety life cycle of hazardous waste landfill based on environmental risk. In the direction of green engineering research, Shi Zhenwu (2019) and others put forward a relatively complete evaluation system for green highway with full life cycle by using analytic hierarchy process. However, at this stage, there is no unified evaluation system for landfills, and various evaluation indicators for landfills are not complete. There is a big vacancy in the study of the life cycle of green landfills. Therefore, in order to have a clearer and more scientific orientation for the improvement of landfills, it is more and more necessary to study the evaluation system of landfills.

In this paper, based on the study of the life cycle of the green landfill, taking Tianziling Landfill as an example, the analytic hierarchy process (AHP) is used to establish a relatively sound evaluation system for the landfill, and the mathematical modelling and model analysis are carried out.

2. Evaluation methods

2.1 Introduction of Analytic Hierarchy Process

Analytic Hierarchy Process (AHP) is a qualitative and quantitative, systematic and hierarchical analysis method proposed by T.L.Saaty, an American operational researcher. The method is to decompose complex problems into various components, group these factors according to certain rule attributes, and then form an orderly hierarchical structure.

In this paper, the basic idea of using analytic hierarchy process (AHP) is as follows: firstly, form the first and second indicators of the green landfill evaluation index system based on life cycle are established and an analytic hierarchy process chart. then, the corresponding weights of each indicator are obtained by quantifying the indicators at each level. The final index weights are obtained by integrating the weights of the first and second indicators. Judgment and analysis finally is based on the final weight.

2.2 Establishment of Evaluation Index

Landfill is a complex engineering construction project. Its construction should not only take into account the difficulty of specific engineering construction technology, but also the impact on the environment in the later period. Based on the construction and operation management index of the whole life cycle of the landfill, this paper adds the "environmental protection" index of the green landfill, and jointly constructs the evaluation system of green landfill based on life cycle. As shown in Figure 1.

![Fig. 1 Green Landfill Evaluation Index System for Life Cycle](image)
2.3 Calculation of Index Weight

The hierarchical structure shown in Fig. 1 shows that the performance A of Tianziling Landfill is mainly restricted by three aspects: engineering construction, environmental protection and operation management. In this hierarchical structure, the engineering construction is restricted by five factors: the final overlay system, leachate drainage and treatment system, landfill gas system, groundwater monitoring system and site selection; environmental protection is affected by six factors: toxic odor concentration, leachate pollutant content, soil quality, groundwater pollution level, pollution in nearby waters and greenhouse gas concentration. Operation management is restricted by four factors: environmental monitoring, garbage inspection, leachate treatment and safety facilities.

By using the analytic hierarchy process, the above-mentioned influence factors are compared with each other, and the judgment matrix is constructed. Finally, the weight of each index is calculated. As shown in the table below:

| Title of first-level indicators         | weight | Names of secondary indicators | weight | Comprehensive weight |
|----------------------------------------|--------|--------------------------------|--------|----------------------|
| Engineering Construction (A_1)         | 0.4934 | Final Overlay System A_{11}    | 0.4024 | 0.1986               |
|                                        |        | Leachate drainage and treatment system A_{12} | 0.2456 | 0.1212               |
|                                        |        | Landfill Gas System A_{13}     | 0.1356 | 0.0669               |
|                                        |        | Groundwater Monitoring System A_{14} | 0.1356 | 0.0669               |
|                                        |        | Site selection A_{15}          | 0.0790 | 0.0390               |
| Environmental Protection (A_2)         | 0.3180 | Toxic odor concentration A_{21} | 0.4160 | 0.1322               |
|                                        |        | Leachate Contaminant Content A_{22} | 0.1785 | 0.0568               |
|                                        |        | Soil Quality A_{23}            | 0.1668 | 0.0530               |
|                                        |        | Groundwater Pollution Level A_{24} | 0.1140 | 0.0362               |
|                                        |        | Pollution in nearby waters A_{25} | 0.0712 | 0.0226               |
|                                        |        | Greenhouse gas concentration A_{26} | 0.0534 | 0.0170               |
| Operation Management (A_3)             | 0.1958 | Environmental Monitoring A_{31} | 0.3509 | 0.0700               |
|                                        |        | Garbage Inspection A_{32}      | 0.1890 | 0.0375               |
|                                        |        | Leachate Treatment A_{33}      | 0.3509 | 0.0700               |
|                                        |        | Safety facility A_{34}         | 0.1091 | 0.0217               |

Among the weights of the index system shown in the table above, engineering construction A_1 is the key point of landfill evaluation. In this link, the weight of the final overlay system A_{11} (0.4024) is the largest, and it also occupies the largest weight (0.1986) in the comprehensive weight. Under the environmental protection A_2 index, the toxic odor concentration A_{21} has the greatest restrictive effect on the suitability of landfill. And in the operation and management link, the contribution of environmental monitoring A_{31} and leachate treatment A_{32} have greater restrictive effect compared with other factors.

3. Case Application and Evaluation

The Hangzhou Tianziling Landfill adopts advanced anti-seepage technology. The combination of vertical anti-seepage and horizontal anti-seepage is adopted for leachate anti-seepage. Besides, the separation of rainwater and sewage and the collection and treatment of leachate are well accomplished. The results of water quality test in recent ten years show that there are no deductions in the evaluation indexes of leachate drainage and treatment system A_{12}, groundwater monitoring system A_{14}, leachate
contamination content A22, groundwater pollution level A24, pollution in nearby waters A25 and leachate treatment A33.

According to the investigation, the biggest problem of Hangzhou Tianziling Landfill is the toxic odor hazard caused by improper disposal of landfill gas. The strong toxic odor emitted by Tianziling Landfill combined with improper site selection has a very negative impact on the lives and health of the surrounding residents. At the same time, a large number of carbon emissions will also promote the intensification of greenhouse effect in this area. Generally, these phenomena are caused by the incomplete construction of the final overburden system and the inadequate environmental monitoring. In conclusion, the main deduction items of Hangzhou Tianziling Landfill exist in the final overlay system A11, landfill gas system A13, site selection A15, toxic odor concentration A21, greenhouse gas concentration A26 and environmental monitoring A31.

According to the comprehensive weight, the present situation of Hangzhou Tianziling Landfill was scored. With 100 points as the full score, the landfill in the 90-100 score range is defined as a high green landfill; the landfill in the 80-90 score range has a good green level; the landfill in the 70-80 score range basically meets the standard; and the landfill below 70 score can be evaluated as an unqualified landfill.

The final score of Hangzhou Tianziling Landfill was 70.3. Therefore, according to the score of this paper, Hangzhou Tianziling Landfill is a basically qualified landfill, which can basically meet the requirements of waste disposal, but there are still many problems to be improved in odor disposal and overlay system, and there is a lot of room for improvement in the goal of green landfill.

4. Conclusion
Based on the construction of landfills and the practical application of landfills in China, this paper puts forward the evaluation index system from three dimensions of engineering construction, environmental protection and operation management. In this paper, the analytic hierarchy process (AHP) is used as a tool to establish the evaluation system. The corresponding hierarchical structure and judgment matrix are established according to the determined indexes. On the basis of ensuring the consistency of the matrix, the weight values of each index are calculated, and the final evaluation system of landfill is established. Based on the evaluation system, Hangzhou Tianziling Landfill scored 70.3 points, and this evaluation system was close to the actual situation. Therefore, the green landfill evaluation system established in this paper has certain rationality, which can provide guidance for the construction and management of future green landfill projects.

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Reference
[1] Obersteiner Gudrun, Binner Erwin, Mostbauer Peter, Salhofer Stefan. Landfill modelling in LCA - A contribution based on empirical data [J]. Waste Magentm, 2007, 27(08):58-74.
[2] Xu Ya, Nai Changxin, Liu Yuqiang, Yang Jinzhong, Liu Jingcai, Dong Lu. Risk-based method to assess the safe life of hazardous waste landfill [J]. China Environmental Science, 2016, 36(06):1802-1809.
[3] Shi Zhenwu, Li Zhaolin, Hua Shuxin. Research on green highway evaluation system based on life cycle [J]. Shanxi Architecture, 2019, 45 (08): 109-111.
[4] Ma Lihai, Li Jun. Construction and application of landfill evaluation index system based on analytic hierarchy process [J]. Environmental protection and circular economy, 2017, 37(05): 72-76.
[5] Huang Xinxia, Lu Da, Li Kongliang, Bai Lijuan. Suitability evaluation of landfill sites around Hefei [J]. Journal of Anhui Polytechnic of Water Conservancy and Hydropower, 2018, 18 (03): 43-46.
[6] Feng Chengkui, Wang Fei, Xu Wenhao, Wu Yimin. Study on comprehensive evaluation index system of highway tunnel life cycle [J]. Journal of Underground Space and Engineering, 2018, 14 (S1): 378-384.

[7] Jin Weiliang, Zhong Xiaoping. Study on the theoretical system of life cycle design for sustainable development engineering structures [J]. China Engineering Science, 2012, 14 (03): 100-107.

[8] Lixi. Study on odor pollution sources in landfills [J]. Science and Technology and Enterprises, 2015 (09): 109.

[9] Hou Tao. Evaluation of suitability for site selection of domestic waste landfill based on analytic hierarchy process [J/OL]. Western Resources, 2019 (02): 80-81 [2019-05-08].

[10] Zou Yinglei, Zhan Yong. Risk Management Based on Project Life Cycle [J]. Engineering Technology Research, 2018 (01): 167-197.