Environmental Risk Assessment Method for Drilling Solid Waste Resource Utilization

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Abstract. With the gradual increase in the comprehensive utilization rate of industrial solid waste, the quality and safety of drilling solid waste recycling products have become increasingly prominent. This article starts with the hazards of drilling solid waste resource products to the human body and the environment, adopts the method of hazard factor identification, constructs a qualitative and quantitative index system for the quality and safety evaluation of solid waste resource products, and proposes corresponding evaluation procedures and countermeasures.

Key words: Drilling solid waste, solid waste recycling, quality and safety, environmental risk assessment.

1. Introduction
The resource utilization of drilling solid waste can not only alleviate the environmental impact of solid waste storage, but also effectively reduce the use of primary mineral resources and alleviate resource shortages. However, industrial solid waste contains toxic components that affect the environment and human health, such as Pb, Ni, Cr, Cd, S, As, etc., which will also enter the environment during the process of recycling, resulting in the production and use of the product. The problem of secondary pollution. Therefore, in the design process of solid waste recycling products, it is necessary to pay special attention to the ecological design of the product in order to reduce the environmental impact of the product and ensure its safe use. Existing product eco-design methods are mainly aimed at the eco-design of native resource products, and there are few studies on drilling solid waste and other secondary resources as raw materials [1]. On the basis of the existing product ecological design methods, the article considers the characteristics of the diversity of solid waste components, analyses the particularity of solid waste resources from raw materials, production processes to products, and initially establishes the ecological design of drilling solid waste resources. Methods, and carry out case studies to provide method support for the ecological design of drilling solid waste resource products.
2. Construction of Evaluation Index System

2.1. Build path

The quality and safety evaluation of solid waste recycling products involves interested parties including manufacturers, governments, sellers and consumers. The construction of the indicator system should be based on product classification, policy and regulation review, standard research, and case analysis. The method of factor identification is to identify the hazard factors in the whole life process of the product and the hazard objects [2]. Hazard factor identification is the identification of factors that cause harm to humans and the environment during the entire life of drilling solid waste recycling products, including identification of the entire life process of the product and identification of hazardous objects, focusing on the identification of hazardous substances and research the law of the migration of harmful substances. A qualitative evaluation index system is constructed through the identification of hazard factors throughout the life of the product, and a quantitative evaluation index system is constructed through the identification of factors of hazard objects. The construction of the qualitative evaluation index system should include four aspects of raw materials, production process, management and the product itself, and the quantitative evaluation index system should include the four aspects of resources, environment and energy, and products (as shown in Figure 1).

![Figure 1](image)

**Figure 1.** Construction path of the quality and safety evaluation index system of solid waste recycling products

2.2. Qualitative index system

According to the principles and methods of evaluation index system construction, establish a qualitative evaluation index system for the quality and safety of solid waste recycling products. The first-level indicators include four first-level indicators of raw materials, production process, management and products (see Table 1).
Table 1. Qualitative evaluation index system for quality and safety of drilling solid waste recycling products

| First level | Level 2 |
|-------------|---------|
| Raw materials | Transport normative Stockpile normative Ingredient safety Other |
| Production process | Technological advancement Detection of harmlessness Document integrity Other |
| Management | Advanced technology management Environmental management science |
| Product | Quality management norms Other Quality reliability |
| | Environmental friendliness Product high value Other |

(1) Raw materials are the evaluation of product raw materials, including the transportation standardization, storage standardization and composition safety of raw materials. (2) The production process is an evaluation of the whole process of product production, including technological advancement, harmlessness of testing, and completeness of documentation. (3) Management is the evaluation of products in terms of management, including advanced technology management, scientific environmental management, and standard quality management. (4) A product is an evaluation of the quality and safety of the product itself, including quality reliability, environmental friendliness, and product high value.

2.3. Quantitative index system

According to the principles and construction methods of the evaluation index system, a quantitative evaluation index system for the quality and safety of solid waste recycling products is established. The first-level indicators include four aspects: resources, energy, environment and products (see Table 2).
Table 2. Quantitative evaluation index system for product quality and safety of industrial solid waste comprehensive utilization

| First level indicator | Secondary indicators | Unit |
|-----------------------|----------------------|------|
| Resources             | Comprehensive utilization rate of solid waste | %    |
|                       | Water consumption per unit product | %    |
|                       | Usage rate of toxic and hazardous materials | %    |
|                       | Other                  |      |
| Energy                | Comprehensive energy consumption per unit product | tce |
|                       | Renewable energy use ratio | %    |
|                       | Other                  |      |
| Surroundings          | Heavy metal emissions per unit product | g/product unit |
|                       | Electromagnetic radiation | A/m  |
|                       | Waste water discharge per unit product | Cubic meter/unit product |
|                       | Waste gas emission per unit product | Cubic meter/unit product |
|                       | Waste residue emissions per unit product | Cubic meter/unit product |
|                       | Other                  |      |
| Product               | Product performance index | According to specific products |
|                       | Product radioactivity index | --   |
|                       | Product heavy metal content | --   |
|                       | Volatile toxic substances | mg/m³ |
|                       | Can dissolve toxic substances | mg/m³ |
|                       | Other                  |      |

(1) Resources are indicators of the consumption and recycling of resources during the whole life of a product. (2) Energy is an indicator of energy consumption and type of use in the production process of a product. (3) Environment is an indicator of the pollutants discharged into the environment during the whole life of the product. (4) Products are indicators of the performance, quality, heavy metals and radioactivity of the product itself, and the migration characteristics of toxic and hazardous substances.

3. Evaluation model

3.1. Determination of weight

This paper adopts the modified entropy weight method to determine the weight of the index. The specific calculation formula is as follows: there are currently m items to be evaluated (where m is the number of years for retrospective evaluation), n evaluation indicators (where n is the number of element indicators), Form the original data matrix \(\{y_{i}\}_{\text{max}}\) representation. For the larger positive indicators, there are:

\[
x_y = \left[ y_i \right] \left[ \sum_{i=1}^{n} y_i \right]^{-1}
\]

For the small negative indicators that are superior, there are:

\[
x_y = \left[ y_i \right] \left[ \sum_{i=1}^{n} y_i \right]^{-1}
\]
Considering that the scores of each principal component after standardization are negative, since the entropy weight method needs to take logarithms, in order to avoid negative numbers and zeros, this paper adopts the method of shifting the data to make corrections [3]. The translation method is to take the minimum value of each item group to be evaluated. If the minimum value is a negative number, perform Gaussian rounding \( \min_{ij} x \) on the minimum negative number, and take its absolute value as the translation amount. The calculation is as follows.

### 3.2. Retrospective evaluation model of pollution reduction performance based on entropy weight multi-objective decision-making

The paper adopts the comprehensive evaluation method of multi-objective decision-making based on entropy weight to evaluate the performance of pollution reduction in the park: After determining the entropy weight, find out the best and worst plan of evaluation index, and then calculate each plan and the best plan and worst plan [4]. The weighted distance of the scheme, and finally determine the order of each evaluated unit according to the distance. The evaluation model is constructed as follows: The first step is to construct a weighted standardized decision matrix:

\[
R = (r_{ij})_{m \times n}, \quad r_{ij} = w_i \times x_{ij} (i = 1, 2, ..., m; j = 1, 2, ..., n) \tag{3}
\]

The second step is to determine the best option \( X^+ \) and the worst option \( X^- \): define \( X^+ = (x_i^+, x_i^+, ..., x_i^+) \), \( X^- = (x_i^-, x_i^-, ..., x_i^-) \). For a positive indicator that is superior to the larger, there is \( x_i^+ = \max_j r_{ij}, x_i^- = \min_j r_{ij} \); for a negative indicator that is superior to the small, there is \( x_i^+ = \min_j r_{ij}, x_i^- = \max_j r_{ij} \).

The third step is to calculate the Euclidean distance between each plan and the optimal plan \( X^+ \) and the worst plan \( X^- \) (\( d_i^+, d_i^- \) respectively):

\[
d_i^+ = \sqrt{\sum_{j=1}^{n} (r_{ij} - x_i^+)^2}
\]

\[
d_i^- = \sqrt{\sum_{j=1}^{n} (r_{ij} - x_i^-)^2}
\tag{4}

The fourth step is to calculate the relative closeness \( S_i \) between each scheme and the ideal solution:

\[
S_i = \frac{d_i^-}{d_i^+ + d_i^-} \tag{5}
\]

The fifth step is to arrange \( (S_i) \) from small to large. The smaller the relative closeness \( (S_i) \) is, the closer the relationship between the evaluation unit and the optimal solution is, the more distant the relationship between the evaluation unit and the worst solution, and the better the effect [5].

### 4. Case Study

We collect environmental statistics on solid waste from a drilling well, especially the exchange and utilization of water, energy, and major waste. Obtain the following data for the national industrial added value during 2013-2019 and the emissions of industrial pollutants COD, ammonia nitrogen, SO2, NOx, etc.; 2013-2019 daily drilling added value, resource land area, reclaimed water reuse, and main production The discharge of major pollutants such as COD, ammonia nitrogen, SO2, NOx and other major pollutants, solid waste and hazardous waste generation, treatment and disposal, and energy consumption and water consumption of enterprises above designated size [6]. The index data is
normalized to construct a standardized matrix, and the results of the obtained schemes and the ideal relative closeness \( S_i \) are shown in Table 3.

| Project | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---------|------|------|------|------|------|------|------|
| \( d^*_i \) | 0.257 | 0.281 | 0.355 | 0.25 | 0.136 | 0.126 | 0.209 |
| \( d^*_j \) | 0.158 | 0.102 | 0.056 | 0.135 | 0.291 | 0.344 | 0.205 |
| S       | 0.619 | 0.734 | 0.865 | 0.65 | 0.319 | 0.268 | 0.506 |
| Rank    | 5    | 8    | 9    | 6    | 2    | 1    | 3    |

The pollution reduction of the park has obvious phase characteristics, and the performance of emission reduction is positively related to the construction process of the drilling industry. The retrospective evaluation results are highly consistent with the actual development of the park, indicating that the established retrospective evaluation index system and method are very good. Locally identify the construction performance of the park. COD and SO\(_2\) emissions and solid waste treatment and disposal were reduced by 518.3t, 3897.5t, and 59,000 tons respectively of these, 58% of COD emissions reductions came from the sharing of infrastructure, 42% came from cleaner production; SO\(_2\) emissions reductions 89% comes from clean production and 11% comes from the symbiosis of the drilling industry; 95% of the reduction in the amount of solid waste treatment and disposal comes from the symbiosis of the drilling industry \[7\]. Therefore, the results of the retrospective evaluation well illustrate the ways of pollution reduction during the construction of the drilling industry and reflect the inherent characteristics of the drilling industry. Take the ratio (the rate of emission reduction of total pollutants, the utilization rate of industrial solid waste resources and the average annual growth rate of industrial added value) as the ordinate, and the construction year of the park (2013-2019) as the abscissa to obtain Rizhao Economic and Technological Development The trend comparison chart of regional and national economic growth rates and total pollutant emission reduction rates is shown in Figure 2.

![Figure 2. Comparative analysis of economic growth and the rate of emission reduction of total pollutants](image)

5. Conclusion
This paper establishes a secondary pollution control system for toxic components, considers the resource attributes of solid waste, treats solid waste as a by-product of the process, and designs and forms evaluation indicators including resource consumption, energy consumption, environmental
pollution, and human health. On this basis, an ecological design method for drilling solid waste resourced products has been formed. With the continuous acceleration of drilling solid waste recycling process, users have higher and higher environmental requirements for recycling products, and the corresponding environmental standards for solid waste recycling products are also being formulated. Therefore, the ecological design of solid waste resource-based products is necessary, and the corresponding environmental standards can better serve the ecological design and application of solid waste resources.

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