Fuzzy matter-element model based on entropy weight
Comprehensive evaluation of atmospheric pollutant emission reduction potential in the port area

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Abstract: Based on the entropy weight and fuzzy matter-element model, the entropy weight method is used to determine the weight coefficient of the evaluation index. The matter element analysis and the calculated entropy weight are used to calculate Euclidean. The degree of proximity has established a fuzzy matter element evaluation model for the entropy weight of atmospheric pollutants in the port area, and completed a comprehensive evaluation of different emission sources in the port area, providing technical support for scientific and effective reduction of air pollutants in the port area.

1. Introduction

The number of sources of atmospheric pollutants in the port area is large, often with varying degrees of contradiction between multiple causes and evaluation systems. Port of atmospheric pollutants emission reduction potential evaluation, it is necessary to take into account the different sources of emissions harbor their own situation, but also taking into account the meteorological conditions, geographical factors, emission reduction technology, ports and other policy requirements, and thus reduce emissions of air pollutants port. The potential indicator system is a multi-factor, multi-level complex system. Therefore, in the process of evaluating the emission reduction of air pollutants in ports, it is inevitable to deal with the contradictions between many systems. To do a good job in evaluating the emission reduction potential, we must master the laws and methods to solve the systemic contradictions.

At present, many scholars at home and abroad have used qualitative, quantitative and qualitative methods to study the potential assessment of atmospheric pollutant emission reduction in different areas, such as analytic hierarchy process and fuzzy comprehensive evaluation.

Although these methods provide qualitative and quantitative decision-making basis to a certain extent, because the evaluation results of various evaluation indicators are often incompatible, it is easy to miss some useful information in decision-making. In the evaluation method of atmospheric pollutant emission reduction potential in the port area, it is often dependent on expert experience to determine the weight of the index. There are many subjective factors, which may cause the decision result to be out of touch with the actual situation and need to be further improved.

The matter-element model is proposed for the incompatibility of the problem[1]. The entropy-weight method is an objective method of weighting. The original information of the weight is directly derived from the objective environment, and is determined according to the amount of information provided by the indicator. The corresponding weight coefficient[2] has been well applied in the calculation of weights in the field of environmental assessment[3, 4]. The organic combination of the
two is applicable to multi-index evaluation problems, with simple calculation, clear concept principle and weight assignment. Objective and other characteristics, currently The entropy weight matter element model has been widely used in many aspects such as water resources carrying capacity evaluation\[^5\], water quality evaluation\[^6\], ecological environment carrying capacity evaluation\[^7\], and urban network risk assessment\[^8\].

Based on the existing theory of atmospheric pollutant emission reduction evaluation in the port area, based on the characteristics of multi-index, ambiguity and incompatibility of the atmospheric pollutant emission reduction potential assessment in the port area, the theory based on entropy weight is established. comprehensive evaluation model Port area air pollutant emission reduction potential and fuzzy matter element analysis, seeks to complement and improve the Port of atmospheric pollutants emission reduction potential evaluation system, to support the development of an optimal port have air pollutant emission reduction policies, It is of great significance to improve the management level of energy saving and emission reduction in the port area.

2. Comprehensive evaluation index system for atmospheric pollutant emission reduction potential in the port area

2.1 Establishment of an evaluation index system

The evaluation of the emission reduction potential of air pollutants in the port area must consider the situation of the source itself and the meteorological and water environment of the port area. The factors that constitute the evaluation index system for the emission reduction potential of air pollutants in the port area are complex. This article in determining Port emission reduction potential evaluation of atmospheric pollutants, mainly from the following aspects: Port meteorological and geographical conditions, the situation of environmental protection measures and the corresponding part of Port management requires three aspects.

2.2 Evaluation of sample selection and quantification of fuzzy indicators

In the evaluation process of atmospheric pollutant emission reduction potential in the port area, the selection of indicators is particularly critical. This paper selects 19 indicators including berth type, berth tonnage, berth construction year, average traffic density, process rationality, climate status, responsibility awareness and energy conservation and emission reduction management system to form a comprehensive evaluation index system for atmospheric pollutant emission reduction potential in the port area. As shown in Table 1. The evaluation index of the specific value adopts the statistical value in the evaluation, and the fuzzy evaluation index such as responsibility consciousness, technical state operability, energy saving and emission reduction management system is standardized on the basis of classification. In the specific processing, the factor level is qualitatively divided into The five levels, corresponding to the quantified values are: 0–0.2, 0.2–0.4, 0.4–0.6, 0.6–0.8, 0.8–1.0, as shown in Table 2.

| Evaluation criteria | Evaluation index |
|---------------------|------------------|
| Port area's own conditions | Berth type |
| | Berth tonnage (GT) |
| | Technical status, manufacturability |
| | Berth construction year (year) |
| Cargo throughput | |
| Average wind speed ( cm/s) | |
| Years of operation (days) | |
| Port area situation | Annual atmospheric treatment costs ( 10,000 yuan / year) |
| | Shore power usage ( % ) |
| | Average ship traffic density ( ships / day) |
| | Technical transformation of accounting case |
| Evaluation criteria | Evaluation index                                                                 |
|---------------------|----------------------------------------------------------------------------------|
|                     | Process rationality                                                              |
|                     | Unfinished environmental protection technology reform project                     |
|                     | New technology revenue                                                            |
|                     | Technical status, operational                                                     |
|                     | Management health                                                                 |
|                     | Sense of responsibility                                                           |
|                     | Business quality                                                                  |
|                     | Environmental management system                                                  |

| Human Factors |                                                                                      |
|---------------|--------------------------------------------------------------------------------------------|
|               | Management health                                                                     |
|               | Sense of responsibility                                                                |
|               | Business quality                                                                      |
|               | Environmental management system                                                      |

| Table 2. Standardization of fuzzy evaluation indicators | Level and standard | Specific division criteria |
|--------------------------------------------------------|--------------------|---------------------------|
| factor                                                 | level standard value | Poor difference general it is good better |
| State of the art, is operable for resistance            | 0-0.2              | 0.2-0.4 0.4-0.6 0.6-0.8 0.8-1.0 |
| Management health                                      | 0-0.2              | 0.2-0.4 0.4-0.6 0.6-0.8 0.8-1.0 |
| Sense of responsibility                                | 0-0.2              | 0.2-0.4 0.4-0.6 0.6-0.8 0.8-1.0 |
| Business quality                                        | 0-0.2              | 0.2-0.4 0.4-0.6 0.6-0.8 0.8-1.0 |
| Environmental management system                         | 0-0.2              | 0.2-0.4 0.4-0.6 0.6-0.8 0.8-1.0 |
| New technology revenue                                  | less               | less general many More |
| Process rationality                                     | simple              | general complex More complicated Very complicated |
| Berth type                                              | bulk cargo          | Oil product Chemicals container passenger ship |
|                                                        | 0-0.2              | 0.2-0.4 0.4-0.6 0.6-0.8 0.8-1.0 |

3. Comprehensive evaluation model for atmospheric pollutant emission reduction potential in the port area

3.1 Establishment of fuzzy matter-element model

(1) Establishment of composite fuzzy matter elements

If the port air pollutant emission reduction potential of \( n \) evaluation \( C_1, C_2, \ldots, C_n \), and fuzzy values of \( v_1, v_2, \ldots, v_n \), \( R \) is an \( n \)-dimensional called fuzzy matter element, abbreviated as \( R = (n, C, v) \). If the port has \( m \) berths, combined with the \( n \)-dimensional fuzzy matter elements of the atmospheric pollutant emission reduction situation, it can constitute a \( m \times n \) port area pollutant emission reduction compound element, if the quantity is rewritten as a fuzzy object The meta-value is called the \( n \)-dimensional composite fuzzy matter element in the \( m \)-zone air pollutant emission reduction situation. denoted as:
In the formula: \( R_{mn} \), also known as \( m \) the case of a reduction of atmospheric pollutants port evaluation index \( n \) of the composite element; \( M_i \) was the reduction of atmospheric pollutants in the \( i-th \) port area, where \( i = 1, 2, \ldots, m \); \( C_i \) was the emission reduction evaluation index, where \( k = 1, 2, \ldots, n \); \( v_{ik} \) was the \( i-th \) fuzzy value corresponding to the emission reduction evaluation index of the atmospheric pollutant emission reduction situation in the port area.

(2) Establishment of fuzzy matter elements with superior membership degree

Fuzzy values of each single evaluation index, the membership degree of fuzzy values corresponding to each evaluation index dependent standard protocol, known as membership favorably, since the membership favorably generally positive, requires the use of the following types of indicators:

The bigger the better: \( \mu_{ik} = v_{ik} / \max (v_{ik}) \)

Smaller and better: \( \mu_{ik} = \min (v_{ik})/v_{ik} \)

Where: \( \mu_{ik} \) is the preferred membership degree; \( \max (v_{ik}), \min (v_{ik}) \) are the maximum and minimum values of all the magnitudes \( v_{ik} \) of each evaluation index in the atmospheric pollutant emission reduction situation of each port area. Constructing a subordinate degree fuzzy matter element \( \tilde{R}_{mn} \):

\[
\tilde{R}_{mn} = \begin{bmatrix}
M_1 & \ldots & M_m \\
C_k & v_{ik} & \ldots & v_{in}
\end{bmatrix}
\]

(2) Establishment of standard fuzzy matter element and difference square compound fuzzy matter element

Standard fuzzy matter element \( R_{on} \) refers to the favored membership degree fuzzy matter element \( \tilde{R}_{mn} \). The optimal value of the superior membership degree of each evaluation index, that is, the larger the better, the larger the value, the smaller the better, the smaller, the lower the value of \( \Delta_{ik} \), the standard fuzzy matter element \( R_{on} \) and the favored membership fuzzy matter element \( \tilde{R}_{mn} \). The square of each difference is composed of the difference square compound fuzzy matter element \( R_{on} \), that is, \( \Delta_{ik}=(\mu_{ik} - \mu_{0})^2 \). The optimal fuzzy value of the superior membership degree of each evaluation index, that is, the fuzzy quantity value of the standard fuzzy matter element \( R_{on} \), then \( R_{on} \) is expressed as:

\[
\Delta_{ik} = \begin{bmatrix}
M_1 & \ldots & M_m \\
C_k & \Delta_{i1} & \ldots & \Delta_{in}
\end{bmatrix}
\]

(3) Evaluation index weight calculation

Analyzing matrix and Construction of the \( m-th \) port emissions of air pollutants in the case of \( n \)-reduction potential evaluation index \( A = (v_{ik})_{mn} \)

\[
A = \begin{bmatrix}
M_1 & \ldots & M_m \\
C_k & v_{ik} & \ldots & v_{in}
\end{bmatrix}
\]

(4)
(2) Normalized calculation
Normalize the judgment matrix to obtain a normalized judgment matrix \( A' \):

\[
A' = \begin{bmatrix}
M_1 & \cdots & M_m \\
C_1 & a_{11} & \cdots & a_{1m} \\
\vdots & \vdots & \ddots & \vdots \\
C_n & a_{n1} & \cdots & a_{nm}
\end{bmatrix}
\]

(5)

For the indicators that are better for the big ones, there are

\[
a_{ik} = \frac{v_{\text{max}} - v_k}{v_{\text{max}} - v_{\text{min}}}
\]

For the indicators that the small one is excellent, there are

\[
a_{ik} = \frac{v_k - v_{\text{min}}}{v_{\text{max}} - v_{\text{min}}}
\]

Where: \( v_{\text{max}} \) and \( v_{\text{min}} \) respectively under the same reduction of atmospheric pollutants index different port in case the maximum potential, that is the higher the greater the reduction potential of the optimal maximum value, the smaller the reduction potential lower take. The minimum value is optimal.

(3) Defining entropy
In the evaluation of the air pollutant emission reduction situation with \( n \) evaluation indicators and \( m \) evaluated regions, the entropy of the \( k \)-th emission reduction potential evaluation index is determined as:

\[
H_k = -\frac{1}{\ln m} \sum_{i=1}^{m} f_{ik} \ln f_{ik}
\]

among them,

\[
f_{ik} = \frac{1 + a_{ik}}{\sum_{i=1}^{m} (1 + a_{ik})}
\]

(7)

(4) Define the entropy weight
After defining the \( k \)-th emission reduction potential evaluation of entropy, get the \( k \)-th entropy defined evaluation indicators, namely:

\[
\omega_k = \frac{1 - H_k}{n - \sum_{k=1}^{n} H_k}
\]

among them.

\[
0 \leq \omega_k \leq 1, \quad \sum_{k=1}^{n} \omega_k = 1
\]

(8)

3.3 Implementation of comprehensive evaluation
The proximity of Euclidean refers to the degree to which the atmospheric pollutant emission reduction situation and the optimal effect in the port area are close to each other. The larger the value, the closer the two are, and vice versa. According to the proximity of Euclidean, the comprehensive evaluation of the atmospheric pollutant emission reduction situation in each port area is ranked to determine the optimal operation effect. The first multiplication and post-addition algorithm is used to calculate the Euclidean proximity, namely:

\[
\rho H_i = 1 - \sqrt{\sum_{k=1}^{n} \omega_k \cdot \Delta_{ik}}
\]

Then, the Euclidean proximity complex fuzzy matter element is established, which is:

\[
R_{\rho H} = \begin{bmatrix}
M_1 & M_2 & \cdots & M_m \\
\rho H_1 & \rho H_1 & \rho H_1 & \cdots & \rho H_1
\end{bmatrix}
\]

(10)
3.4 Application examples
The use of entropy created by fuzzy matter element model to evaluate the potential of a port berth four domestic emissions of air pollutants, various atmospheric pollutants emission reduction potential comprehensive evaluation parameters in Table 3 and Table 4. Table 4 Data Indicators The post-evaluation data was processed using the standardization method of Table 2.

Table 3. Original indicator for comprehensive evaluation of atmospheric pollutant emission reduction potential in the port area

| Evaluation index value | Evaluation target 1 | Evaluation target 2 | Evaluation target 3 | Evaluation target 4 |
|------------------------|---------------------|---------------------|---------------------|---------------------|
| Berth type             | Bulk berth          | Oil berth           | Container berth     | Miscellaneous berth |
| Berth tonnage          | 5000                | 1000                | 1000                | 3000                |
| Technical status, manufacturability | better | it is good | general | it is good |
| Berth construction year | 8                   | 10                  | 13                  | 15                  |
| Cargo throughput       | 0.03                | 0.02                | 0.005               | 0.003               |
| Average wind speed     | 89                  | 103                 | 96                  | 111                 |
| Years of operation     | 68                  | 57                  | 67                  | 75                  |
| Annual atmospheric treatment costs | 33 | 41 | 35 | 38 |
| Shore power usage      | 1.3                 | 1.67                | 2.3                 | 2.56                |
| Average ship traffic density | 48 | 52 | 67 | 99 |
| Technical transformation of accounting case | 1/5 | 2/11 | 1/6 | 2/9 |
| Process rationality    | More complicated    | More complicated    | Very complicated    | Very complicated    |
| Unfinished environmental protection technology reform project | general | general | More obstacles | More obstacles |
| New technology revenue | better              | it is good          | general             | general             |
| Management health      | it is good          | it is good          | general             | general             |
| Sense of responsibility| it is good          | it is good          | it is good          | it is good          |
| Business quality       | better              | general             | better              | general             |
| Green Environmental Management Regulation | general | better | it is good | general |

Table 4. Specific indicator values for comprehensive evaluation of atmospheric pollutant emission reduction potential in the port area

| K1 | K2 | K3 | K4 |
|----|----|----|----|
| 11 | 0.7 | 0.75 | 0.9 | 0.4 |
| 12 | 450 | 1000 | 2500 | 150 |
| 13 | 0.66 | 0.46 | 0.35 | 0.45 |
| 14 | 8 | 10 | 13 | 15 |
| 15 | 0.03 | 0.02 | 0.005 | 0.003 |
| 16 | 89 | 103 | 96 | 111 |
| 17 | 68 | 57 | 67 | 75 |
| 18 | 33 | 41 | 35 | 38 |
| 19 | 1.3 | 1.67 | 2.3 | 2.56 |
| 110 | 48 | 52 | 67 | 99 |
| 11 | 1/5 | 2/11 | 1/6 | 2/9 |
| 112 | 0.66 | 0.65 | 0.91 | 0.9 |
| 113 | 0.52 | 0.51 | 0.9 | 0.89 |
| 114 | 0.86 | 0.72 | 0.52 | 0.53 |
| 115 | 13 | 11 | 16 | 21 |
| 116 | 0.6 | 0.6 | 0.5 | 0.5 |
| 117 | 0.72 | 0.73 | 0.78 | 0.75 |
| 118 | 0.85 | 0.8 | 0.8 | 0.6 |
| 119 | 0.5 | 0.9 | 0.7 | 0.5 |
3.5 Results analysis
The calculation results of each step are as follows

(1) Evaluation of index normalization calculation results

|   | K1    | K2    | K3    | K4    |
|---|-------|-------|-------|-------|
| I1| 0     | 0.64516| 1.00000| 0.67742|
| I2| 0     | 0.41176| 1.00000| 0.97059|
| I3| 0.28571| 0     | 0.71429| 1.00000|
| I4| 1.00000| 0.33333| 0     | 0.66667|
| I5| 0     | 1.00000| 0.20000| 1.00000|
| I6| 1.00000| 0.33333| 0     | 0.66667|
| I7| 0.60000| 0.70000| 1.00000| 0     |
| I8| 0.12766| 0.36170| 1.00000| 0     |
| I9| 0     | 0.28571| 0.71429| 1.00000|
| I10| 1.00000| 0.62963| 0.07407| 0     |
| I11| 0     | 0.65636| 0.31818| 1.00000|
| I12| 0.61111| 0     | 0.55556| 1.00000|
| I13| 0     | 1.00000| 0.25000| 0.62500|
| I14| 0     | 0.29365| 0.79365| 1.00000|
| I15| 0     | 0.07843| 0.37255| 1.00000|
| I16| 0.60000| 0.27273| 0     | 1.00000|
| I17| 0.03846| 0     | 1.00000| 0.96154|
| I18| 0.02564| 0     | 1.00000| 0.97436|
| I19| 0.20000| 0     | 0.50000| 1.00000|

(2) Evaluation index weight calculation

\[ W = \begin{bmatrix} 0.04123 & 0.05425 & 0.04102 & 0.04864 & 0.05996 & 0.04574 & 0.04073 & 0.04847 & 0.05047 & 0.05746 \\ 0.04706 & 0.07619 & 0.07820 & 0.05191 & 0.04964 & 0.04864 & 0.04569 & 0.06434 & 0.05035 \end{bmatrix} \]

(3) Euclidean proximity calculation

\[ R_{\text{Euclidean}} = \begin{bmatrix} 1 & 0.6927 & 0.6683 & 0.6274 & 0.6751 \end{bmatrix} \]

(1) Sorting the proximity of Euclidean is shown in Figure 1. It can be seen from the figure that the comprehensive evaluation scores of atmospheric pollutant emission reduction potential are from high to low: K1, K4, K2, K3. From the evaluation results, K1 The port area has the highest scoring potential, and the K1 berth is mainly bulk cargo ; K2 port area and K4 port, although the dominant factors are different, the Euclidean proximity of the two is very small, and the two have the same emission reduction potential ; The K3 berth has the lowest emission reduction potential, mainly due to the fact that the berth has completed the proportion of higher technical upgrading projects.

![Figure 1](image-url)

Figure 1 The Euclidean proximity comparison of air pollutant emission reduction potential
Figure 2 Comparison of evaluation index weights

The weights of the various evaluation indicators are compared as shown in Figure 2. It can be seen from the figure that in the established comprehensive evaluation index system for atmospheric pollutant emission reduction potential, the first two rankings of indicator weights are unfinished skill technological transformation projects and process rationality, and their weights are 0.07820 and 0.07619, which are atmospheric. important underlying factor of pollutant emission reduction potential; the latter two indicators were weighted sort of professional quality and throughput, its weight is 0.06434 and 0.05996. The indicators see a large difference in the evaluation ratio, and entropy is a measure of the degree of disorder of the system. The weight coefficient determined by the entropy method is calculated according to the degree of change of each index in the overall evaluation index, so it is more in line with multi-regional air pollution. Comparative evaluation of the potential for material abatement analysis.

4. Conclusions
Firstly, the establishment of a comprehensive evaluation model Port atmospheric pollutant emission reduction potential based on entropy fuzzy matter element and applied to evaluate different emission reduction potential of a port berth, the following conclusions:

1) The weights determined by the entropy weight method show that unfinished skill technological transformation projects and process rationality are important factors affecting the emission reduction potential of air pollutants in the port area. With the improvement of those management measures and operational management requirements, technology projects and construction processes reasonable degree of skill work in the future will be the main port of air pollutant emissions.

2) The evaluation method used in this paper is intuitive, the calculation is simple, and the weight of the index is calculated by the entropy weight method, which avoids the interference of subjective factors and maximizes the objectivity of weight calculation. The comparison of the evaluation results shows that the method The application of the evaluation and analysis of atmospheric pollutant emission reduction potential in the port area is reasonable, feasible and practical.

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