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Original Research Paper

Application of Entropy Weight TOPSIS Method for Optimization of Wastewater Treatment Technology of Municipal Wastewater Treatment Plant

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ABSTRACT

The paper aims to find out the best wastewater pollution control technology of high efficiency and low energy consumption in the Municipal wastewater treatment plants. The method of entropy weight TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) was used to build the estimate model for wastewater treatment technology of the plant. Choice of three municipal wastewater treatment plant processes is A/O, BIOLAK and A^2/O. The close degree calculated by the entropy weight TOPSIS respectively is 0.4530, 0.4987 and 0.5176 in the treatment process suited for the municipal sewage treatment. The A^2/O treatment process is the best, then is the A/O treatment and the worst is the BIOLAK treatment process. Entropy weight TOPSIS method, used in the assessment of the wastewater treatment technology is flexible, convenient, scientific and suitable for the assessment of sewage disposal technology.

INTRODUCTION

The optimization of sewage treatment process is scheduled to order the superiority of the limited wastewater treatment technology scheme by assessing them, and then choosing the best from them, which will be the top issue faced by the wastewater treatment engineering in recent years (Huang 2006, Wang 2010, Deng 2010, Li 2006, Tian 2009). Many kinds of methods to evaluate the wastewater treatment process have been adopted (Wu 2010, Li 2010, Yue 2003). Entropy TOPSIS method has been applied to evaluate urban water supply scheme optimization and groundwater quality.

The quality of municipal sewage water is complex since the water volume is large and the process is not uniform. In recent years the assessment of the sewage treatment technology almost uses the subjective weighting method, such as analytic hierarchy process (AHP), in order to avoid the interference of subjective factors. In this paper, we adopt the objective weighting method namely entropy weight method combined with the TOPSIS for optimization and evaluation of the municipal sewage treatment process.

The TOPSIS Method

Principle of TOPSIS method: TOPSIS method (Technique for Order Preference by Similarity to Ideal Solution) is the English abbreviation of the ranking method approaching to ideal solution, and is a kind of effective method commonly used at multiple attribute decision analysis. It attributes the problems with the ideal solution and negative ideal solution scheme to focus on all rankings.

Entropy weight method: In the use of TOPSIS method, the weight of the design is an important content which has important influence on the evaluation results. Adopting the entropy weight method to determine the index weight can be better to eliminate the subjectivity of the weight factors, making the results of evaluation more actual.

The basic idea of entropy weight method is to consider that the bigger the difference degree, the index is more important, and the corresponding weights are bigger.

Sewage Treatment Process Evaluation Model of Entropy Weight TOPSIS

Construction of the indicator system of sewage treatment process: There are many factors influencing sewage treatment; the authors have constructed the index system of wastewater treatment process, based on analysing the status quo of wastewater treatment process of industrial enterprises, one of which is efficiency index, the other four are cost index (Table 1).

Entropy Model - The Determination of Index Weight:
1. Standardization of decision matrix by standard 0-1 method.
2. The determination of index weight.

According to the definition of entropy, the *n* evaluation index of *M* evaluated object, can determine the entropy of the j^{th} evaluation index:

$$H_j = -\frac{1}{\ln m}\left[\sum_{i=1}^{m} f_{ij} \ln f_{ij}\right], \qquad ...(1)$$

In the formula,

$f_{ij} = (1 + b_{ij}) / \sum_{i=1}^{m} (1 + b_{ij}), i = 1,2,3 ,.. , m ; j = 1,2,3 ,.. , m$。

Calculate the corresponding entropy weight

$$w_j = \frac{1 - H_j}{n - \sum_{j=1}^{n} H_j} \quad ...(2)$$

In the formula, $\sum_{j=1}^{n} w_j = 1$

TOPSIS model - optimization of evaluation of sewage treatment process:

- The standard weighted array C.
- Determine the ideal solution vectors C^+_j and minus ideal solution vectors C^-_j.
- The distance of every solution to the ideal solution and negative ideal solutions S^+_i, S^-_i.
- The close degree of the plan for the ideal solution.
- According to the E^+_i by large to small arrangement plan the character of the order.

THE CASE STUDY

According to the determined sewage treatment process evaluation index system and entropy weight TOPSIS model, we have chosen three typical wastewater treatment processes of municipal sewage treatment plants and judged the quality evaluation of each scheme, so as to determine the optimal municipal sewage treatment process.

Evaluation of index assignment: The Sewage treatment process evaluation index system namely index type is given in Table 1.

Establish initial evaluation matrix A =

$$\begin{bmatrix} 65.51529 & 6.12968 & 5518.519 & 4966.667 & 2185.185 \\ 83.59021 & 7.655342 & 12733.33 & 15698.63 & 13168.22 \\ 84.32935 & 8.468493 & 5428.983 & 8366.667 & 2328.767 \end{bmatrix}$$

Apply entropy model: The initial evaluation matrix standardized B =

$$\begin{bmatrix} 0.0108 & 0 & 1.0000 & 0.8999 & 0.3953 \\ 0.9952 & 1.0000 & 0.1890 & 0 & 0.1613 \\ 0.9909 & 1.0000 & 0.3515 & 0 & 0.7224 \end{bmatrix}$$

Confirm the index weight

$W_i = [0.2407 \quad 0.2497 \quad 0.1479 \quad 0.2876 \quad 0.0741]$

Application of TOPSIS Model

1. Calculation of standardization weighted matrix

Table 1: Sewage treatment process evaluation index system namely index type.

Index	Index type
COD removal rate β (%)	Efficiency
Unit design processing power investment θ (Yuan/ton)	Cost type
Unit wastewater quantity running costs λ (Yuan/ton)	Cost type
Unit hours running costs μ (Yuan/h	Cost type
Unit wastewater quantity power consumption ρ (KWH/tons)	Cost type

$$C = \begin{bmatrix} 0.0026 & 0 & 0.1479 & 0.2588 & 0.0293 \\ 0.2396 & 0.2497 & 0.0280 & 0 & 0.0119 \\ 0.2386 & 0.2497 & 0.0520 & 0 & 0.0535 \end{bmatrix}$$

2. Determination of the ideal solution C^+ and minus ideal solution C^- vectors of standardized matrix C.

The ideal solution C^+ and minus ideal solution C^-, respectively are:

$C^+ = [0.2396 \quad 0.2497 \quad 0.1479 \quad 0.2588 \quad 0.0535]$

$C^- = [0.0026 \quad 0 \quad 0.0280 \quad 0 \quad 0.0119 \quad]$

3. Calculation of the close degree

The distance of each sewage treatment process with the optimal scheme and the worst scheme S^+_i, S^-_i and the close degree E^+_i, are given in Table 2.

The Table 3 shows that the close degree of wastewater treatment process of the three municipal wastewater treatment plans respectively is: sewage plant A 0.4530, sewage plant B 0.4987 and sewage plant C 0.5176. And then come

Table 2: Evaluation index value of municipal wastewater treatment.

Sewage treatment process	Sewage plant A	Sewage plant A	Sewage plant A
	A/O	BIOLAK	A^2/O
COD removal rate (%)	65.5	83.6	84.3
Unit design processing power investment (Yuan/ton)	6.13	7.66	8.47
Unit wastewater quantity running costs (Yuan/ton)	5518.52	12733.33	5428.98
Unit hours running costs (Yuan/h)	4966.67	15698.63	8366.67
Unit wastewater quantity power consumption (KWH/tons)	2185.19	13168.22	2328.77

Table 3: Comprehensive evaluation value of the assessment process.

Municipal wastewater treatment plant	Water treatment process	Distance of ideal solution S^+_i	Distance of minus ideal solutions S^-_i	Close degree E^+_i
A	A/O	0.3451	0.2858	0.4530
B	BIOLAK	0.4497	0.4474	0.4987
C	A^2/O	0.5276	0.5661	0.5176

to the pros and cons sort of three wastewater treatment plants: C/B/A, A^2/O process is better than the BIOLAK technology, and the BIOLAK is better than A/O process.

CONCLUSIONS

Sewage treatment process evaluation is a complex problem; the paper has tried to use the entropy weight TOPSIS method in the field of municipal sewage treatment process evaluation, and the research conclusions are as follows:

1. According to the analysis of the current situation of wastewater treatment process evaluation, determine five economic and technical indexes from many of the influential factors of the wastewater treatment process; build the evaluation index system of sewage treatment process.
2. Based on the analysis of entropy and TOPSIS method, build the entropy weight evaluation model of sewage treatment process.
3. Use Matlab software to programme the entropy weight TOPSIS method, assess sewage treatment process of A, B and C, the three municipal wastewater treatment plants. Obtain the close degree of three sewage plants: sewage plant A 0.4530, sewage plant B 0.4987, sewage plant C 0.5176. The result is sewage treatment effect of sewage plant C is better than sewage plant B and A; sewage plant A is worst.

   TOPSIS method is not strictly limited for data distribution, index and sample size, entropy weight method to avoid subjective judgment of uncertainties; combining the two methods to use for sewage treatment process evaluation is a very feasible method.

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REFERENCES

Deng, R.J., Bo, Z. and Zhou, S.J. 2010. The triangular fuzzy number analytic hierarchy process (AHP) choose small sewage treatment process. Environment Engineering, 28(1): 91-93.

Huang, M., Lu, Y., Xv, L.W. and Zhang, X.H. 2006. Reward-based osculating value method for selection of wastewater treatment process. Environmental Pollution and Control, 28(7): 512-514.

Liu, L., He, J.X. and Gao, Q. 2010. Application of the TOPSIS model based on entropy weights to the optimization of water supply scheme. Journal of Water Resources and Water Engineering, 21(3): 62-65.

Li, X.D. 2006. Levels-A gray correlation analysis method and its application in wastewater treatment plan optimization of application. Taiyuan Technology University.

Tian, W.P., Fu, X.Y. and Chen, X.M. 2009. Value engineering theory and analytic hierarchy process in the sewage treatment scheme is selected application. Energy and Environment, 2: 13-15.

Wang, W., Jiang, J., Wu, X.H., Zhang, B.P. and Gao, K.H. 2010. Application of partial connection number in optimization of urban sewage treatment program. China Water and Wastewater, 26(1): 90-95.

Wu, J.H., Li, P.Y., Song, B.D. and Fang, Y. 2010. Based on entropy weight TOPSIS method is used in the groundwater quality evaluation. Ningxia Engineering Technology, 9(4): 326-329.

Yue, C.Y. 2003. Decision theory and method. Science Press, Beijing.