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Water quality evaluation based on improved fuzzy matter-element method

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Abstract

For natural water, method of water quality evaluation based on improved fuzzy matter-element evaluation method is presented. Two important parts are improved, the weights determining and fuzzy membership functions. The coefficient of variation of each indicator is used to determine the weight instead of traditional calculating superscales method. On the other hand, fuzzy matter-elements are constructed, and normal membership degrees are used instead of traditional trapezoidal ones. The composite fuzzy matter-elements with associated coefficient are constructed through associated transformation. The levels of natural water quality are determined according to the principle of maximum correlation. The improved fuzzy matter-element evaluation method is applied to evaluate water quality of the Luokou mainstream estuary at the first ten weeks in 2011 with the coefficient of variation method determining the weights. Water quality of Luokou mainstream estuary is dropping from level I to level II. The results of the improved evaluation method are basically the same as the official water quality. The variation coefficient method can reduce the workload, and overcome the adverse effects from abnormal values, compared with the traditional calculating superscales method. The results of improved fuzzy matter-element evaluation method are more credible than the ones of the traditional evaluation method. The improved evaluation method can use information of monitoring data more scientifically and comprehensively, and broaden a new evaluation method for water quality assessment.

Key words: water quality; improved fuzzy matter-element evaluation method; synthetic evaluation; variation coefficient method; normal membership

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Introduction

With development of economic and improvement of living standards, our environment, especially natural water, is constantly being polluted. Natural water plays an important role in a watershed for carrying off municipal and industrial wastewater and run-off from farm land (Kunwar et al., 2004, 2005). Pollution with chemical, physical and biological contaminants by anthropogenic activities is of great environmental attention all over the world (May et al., 2006; Noori et al., 2010; Ouyang et al., 2006).

There are various solutes in natural water, such as dissolved oxygen (DO), biochemical oxygen demand (BOD), and chemical oxygen demand (COD) and so on, which influence water quality. According to environmental quality standards (GB3838-2002), for each solute, different concentration values are consistent with different unilateral levels. However, synthetic level of water quality is not a simple combination of all unilateral levels of solutes. Thus the study on synthetic evaluation of water quality which takes some important solutes as indicators and their concentration, becomes a hot issue. There have been various quality evaluation models and methods. A new algorithm for grey relational degree for Han Jiang River was proposed, and a more precise and finer grading of the overall water quality was given (Ip et al., 2009). The training, validation and application of Artificial Neural Networks models were described to compute DO and BOD levels in the Gomti River (Kunwar et al., 2009). Surface water quality of Miyun Reservoir was monitored using remote sensing method based on the empirical correlation between the water quality parameters and band combinations of image (Zhang et al., 2009). The information entropy theory and the fuzzy mathematics method are combined to establish an improved fuzzy comprehensive evaluation method to solve the zero-weight problem (Liu et al., 2010). An index model for quality evaluation of surface water quality classification was proposed using fuzzy logic (Yilmaz, 2007). Principal component analysis and principal factor analysis techniques were applied to evaluate the effectiveness of the surface water quality-monitoring network in a river (Ouyang, 2005).

The matter-element model is composed of objects, characteristics and values based on certain characteristics. If the values are fuzzy, it is called fuzzy matter-element. The content and the relationship between the quality and the quantity of the comprehensive evaluation can be clearly illustrated. It has been widely used in many fields, including pattern recognition, scientific decisions,

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and comprehensive evaluation, etc. (Jing et al., 2000; He et al., 2011). In fuzzy matter-element evaluation method, evaluation indicators are features of the matter, and levels of indicators are fuzzy values. Correlation transformation is operated on fuzzy membership degrees, and composite fuzzy matter-element is constructed using correlation coefficients. Then the level of the matter evaluated can be determined, according to the principle of maximum correlation (Li et al., 2009). It can use information scientifically and rationally. It is an effective evaluation method.

In fuzzy matter-element evaluation of water quality, the weights of indicators in natural water are to measure their impact on water pollution, and they are of great importance. Obviously the greater the weight of an indicator is, the greater its impact is on water quality. In the typical method of synthetic evaluation, the determination of the weight of every indicator is to calculate the superscales which are the ratio of the value of each indicator at every monitoring point over the corresponding one of water quality standard (Zhou et al., 2009). However, they have many limitations of the method of calculating the superscales to apply in definition of weights, such as tedious calculation, heavy workload, and no considering the link between multiple indicators, and so on. Especially the workload, the weight of each indicator should be calculated under each evaluating object. When there are multiple evaluating objects, the workload would be much too heavy. Also, the values monitored actually at every monitoring point would be used in the method of calculating the superscales. Therefore, when the values monitored were actually abnormal or weird, they would not contain the information of the individual indicator well. Thus the abnormal values would have bad effect on the definition of weights. In addition, subjective methods of determining the weight, for example, Analytic Hierarchy Process, are also in use, but this may cause the bias of evaluation results because of subjective factors (Li et al., 2006). To solve the problems above, Zou et al. (2006) proposed a new weight evaluation process using entropy method. For the same effect, variation coefficient method for determination of weights can also be used in water quality assessment. It is based on actual data of indicators which reflects the changes of objective information (Xun et al., 2007). Thus it is an objective method, and can reduce effects of subjective factors. It is a simple calculation, which simplifies fuzzy evaluation process greatly. The workload can be reduced evidently. Another remarkable character is to avoid equalization of weights distribution.

In the previous study of fuzzy evaluation for water quality, trapezoidal membership functions are mostly used (Andre et al., 2009). In each section, linear functions are used to describe the membership. But in reality, the situation is often non-linear. Numerous studies show that when observed more frequently, the membership functions can be approximately seen as normal distribution (Song et al., 2008). Traditional trapezoidal membership functions are replaced by normal membership ones, and in each interval a linear function is replaced by a nonlinear one. This is more reasonable and effective.

In this article, the variation coefficient method is used to determine the weights of indicators in natural water. Normal membership functions are constructed instead of traditional trapezoidal ones. Then improved fuzzy matter-element evaluation method is used to evaluate water quality. It was applied to evaluate the water quality of the Luokou mainstream estuary at the first ten weeks in 2011, compared with traditional fuzzy comprehensive evaluation method and gray clustering evaluation method.

1 Determination of weights

The variation coefficient method for determination of weights is used in this study. In this method, weights are determined according to the variation degree of concentration of various indicators in natural water. In the evaluation system, an indicator is of the greater coefficient of variation, which indicates that the greater degree of variation the index value has, and the more information it provide, the larger its role is in the comprehensive evaluation, and the greater its weight is. Otherwise, an indicator is of the smaller coefficient of variation, which indicates that the smaller degree of variation the index value has, and the less information it provide, the smaller its role is in the comprehensive evaluation, and the smaller its weight is. This method is to highlight the magnitude of relative changes of each indicator. Great coefficient of variation means that it varies greatly at different objects. Thus it has good ability of distinguish, and it should be given a high priority. Thus various levels can be distinguished well as a result of the variation (Xu et al., 2007). The weight set of this method is obtained by the concentration values of all indicators in all monitoring sections. They are calculated as follows.

(1) The original concentration values of all indicators should be normalized to eliminate the impact of dimension. Eq. (1) is used to normalize the concentration values of the benefit indicators, such as DO:

$$u_{ij} = \frac{x_{ij} - \min\limits_i\{x_{ij}\}}{\max\limits_i\{x_{ij}\} - \min\limits_i\{x_{ij}\}} \quad (1)$$

As for the cost indicators, such as COD, it is as Eq. (2):

$$u_{ij} = \frac{\min\limits_i\{x_{ij}\} - x_{ij}}{\max\limits_i\{x_{ij}\} - \min\limits_i\{x_{ij}\}} \quad (2)$$

where, x_{ij} is the concentration on the section j of indicator i, and u_{ij} is a dimensionless parameter normalized. $i = 1, 2, \cdots, m$, and $j = 1, 2, \cdots, n$.

(2) Then u_{ij} is used to calculate D_i which is the variance of concentration of indicator i.

$$D_i = \sqrt{\frac{1}{n}\sum_{j=1}^{n}(u_{ij} - \bar{u}_i)^2}$$

where, $\bar{u}_i$ is the mean of concentration values, that is, $\bar{u}_i = \frac{1}{n}\sum\limits_{j=1}^{n} u_{ij}$.

(3) The variation coefficient (c_i) of indicator i is calculated as Eq. (3):

$$c_i = D_i \times \sqrt{\bar{u}_i} \quad (3)$$

(4) The weights of all indicators can be obtained by normalizing the variation coefficient c_i as Eq. (4):

$$w_i = c_i / \sum_{i=1}^{m} c_i \quad (4)$$

Then the weight system of this method is $W = (w_1, w_2, \cdots, w_m)$, $w_i > 0$, $i = 1, 2, \cdots, m$, and $\sum_{i=1}^{m} w_i = 1$.

2 Improved fuzzy matter-element evaluation method

2.1 Fuzzy matter-element

Given the name of the matter N, its value of feature C is v. The basic elements of things, which are shortly titled as matter-element, are described with ordered triple "matter, feature, value", that is, $R = (N, C, v)$ (Yang et al., 2010). If v is fuzzy, it is called fuzzy matter-element. If a matter has n features $C_1, C_2, \cdots, C_n$ and corresponding fuzzy values $v_1, v_2, \cdots, v_n$, R is called n dimensions fuzzy matter-element, also denoted by $R = (N, C, v)$. m matters with n dimensions matter-element form composite matter-element R_{mn}. If values of R_{mn} are fuzzy, it is called n dimensions composite fuzzy matter-element, denoted by:

$$\tilde{R}_{mn} = \begin{bmatrix} & C_1 & C_2 & \cdots & C_n \\ M_1 & \mu_{11} & \mu_{12} & \cdots & \mu_{1n} \\ M_2 & \mu_{21} & \mu_{22} & \cdots & \mu_{2n} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ M_m & \mu_{m1} & \mu_{m2} & \cdots & \mu_{mn} \end{bmatrix} \quad (5)$$

where, M_i is matter i, and $i = 1, 2, \cdots, m$; C_j is feature j, and $j = 1, 2, \cdots, n$; μ_{ij} is the fuzzy value of matter i on feature j, that is, the membership.

2.2 Normal membership functions

In previous study of fuzzy evaluation for water quality, trapezoidal membership functions are mostly used (Andre et al., 2009). The expression is:

$$\mu(x) = \begin{cases} 0, & x \leqslant a \\ \dfrac{x-a}{b-a}, & a \leqslant x \leqslant b \\ 1, & b \leqslant x \leqslant c \\ \dfrac{d-x}{d-c}, & c \leqslant x \leqslant d \\ 0. & x \geqslant d \end{cases}$$

where, $a, b, c, d > 0$, and they are the characteristic parameters of the function; x stands for the concentration of a monitoring indicator. Some of traditional membership functions are triangle or lower semi-trapezoidal ones, but they are special trapezoidal ones essentially.

From the function we can see that in each interval, a linear function is used to express the membership. However, in reality, the situation is often non-linear. When water quality is observed more frequently, its membership function can be approximately seen as normal distribution (Wang et al., 2004). The expression is as follows:

$$\mu(x) = \exp\left[-\left(\frac{x-a}{b}\right)^2\right] \quad (6)$$

where, $a>0$, $b>0$, and they are the characteristic parameters of the function; x stands for the concentration of a monitoring indicator. Function graphs of trapezoidal membership and normal membership one are shown in Fig. 1. This study replaces traditional trapezoidal membership function with normal membership one. This is more reasonable and effective.

In environmental quality standards for surface water (GB3838-2002), water quality is classified as five levels. Thus the evaluation set is V = {I, II, III, IV, V}. There are multiple indicators in Water Quality Standards. Some of them used in this study are showed as Table 1, and they are the basis for determining μ_{ij} in $\tilde{R}_{mn}$. For the concentration of DO in Table 1, standards for Level I are "saturation rate is 80%" or 7.5 mg/L, and 7.5 will be used in this study.

From Eq. (6), when $x = a$, $\mu(x) = 1$, which is the maximum value. Obviously, when $\mu(x)$ takes the maximum value 1, x must be the middle value of the interval $[x_l, x_u]$ according to the quadratic function. Thus parameter a is the average of two the corresponding boundary values in Table 1. The formula is as follows,

$$a = \frac{x_u + x_l}{2} \quad (7)$$

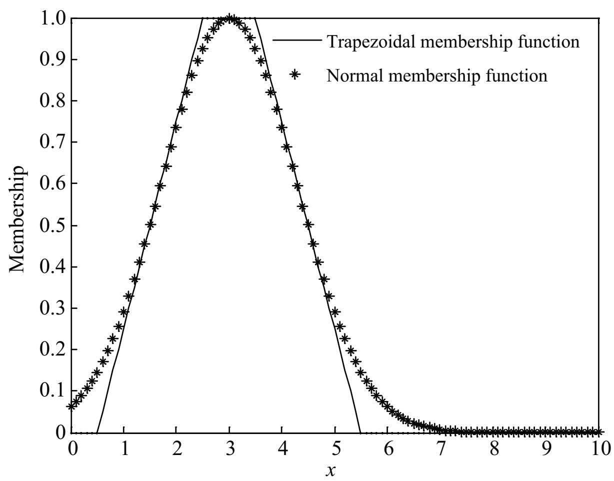

Fig. 1 Function graphs of trapezoidal membership and normal membership.

Table 1 Boundary values of some indicators in Water Quality Standards (GB3838-2002)

Indicator	I	II	III	IV	V
pH			6–9		
DO (mg/L)⩾	7.5	6	5	3	2
COD (mg/L)⩽	15	15	20	30	40
NH_3-N (mg/L)⩽	0.15	0.5	1	1.5	2

where, x_u and x_l are the upper and lower boundary values of corresponding level. Moreover, a boundary value of one level is the transition value from a level to the next, and it should belong to the two levels at the same time. Thus memberships of these two levels equal now, while memberships of other levels are 0. Also sum of memberships of all levels must be 1. Thus we have:

$$\mu(x) = \exp\left[-\left(\frac{x_u - \frac{x_u+x_l}{2}}{b}\right)^2\right] = \frac{1}{2}$$

then

$$b = \frac{x_u - x_l}{2\sqrt{\ln 2}} \tag{8}$$

According to the standard boundary values of all indicators in Table 1, parameters a and b of normal membership functions are calculated. The results are shown in Table 2.

Substitute a, b and actual observed concentration of each indicator into Eq. (6), μ_{ij} in $\tilde{R}_{mn}$ can be obtained.

2.3 Correlation transformation

All the functions to describe the value of extension set with the algebraic expression are called correlation functions (Yang et al., 2010). When a particular value is known in the correlation function, the corresponding function value can be calculated. This function value is called correlation coefficient. The transformation between correlation coefficient and membership associated with is called correlation transformation (Wang et al., 2004). The correlation function and the membership one are equivalent, so the correlation coefficient can be determined by the value of membership function. Thus we have:

$$\xi_{ij} = \mu_{ij} \tag{9}$$

where, ξ_{ij} is the correlation coefficient of indicator i on level j.

Hereby we establish composite fuzzy matter-element with correlation coefficient. According to correlation transformation, each membership in Eq. (5) is converted to the corresponding correlation coefficient. Thus composite fuzzy matter-element with correlation coefficient, denoted by $\tilde{R}_\xi$ is obtained.

$$\tilde{R}_\xi = \begin{bmatrix} & C_1 & C_2 & \cdots & C_n \\ M_1 & \xi_{11} & \xi_{12} & \cdots & \xi_{1n} \\ M_2 & \xi_{21} & \xi_{22} & \cdots & \xi_{2n} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ M_m & \xi_{m1} & \xi_{m2} & \cdots & \xi_{mn} \end{bmatrix} \tag{10}$$

Table 2 Parameters a and b of normal membership functions

Indicator	Parameter	I	II	III	IV	V
DO	a	6.7500	5.5000	4.0000	2.5000	1.0000
	b	0.9009	0.6006	1.2012	0.6006	1.2012
COD	a	7.5000	7.5000	17.5000	25.0000	35.0000
	b	9.0090	9.0090	3.0030	6.0060	6.0060
NH_3-N	a	0.0750	0.3250	0.7500	1.2500	1.7500
	b	0.0901	0.2102	0.3003	0.3003	0.3003

2.4 Correlation analysis

Correlation analysis is operated on water quality in natural water. AlgorithmM(· ,+), that is, operation mode of multiplying and then adding is used. Set $\tilde{R}_k$ as composite fuzzy matter-element with m correlation coefficients, then

$$\tilde{R}_k = R_w \cdot \tilde{R}_\xi = \begin{bmatrix} & C_1 & C_2 & \cdots & C_n \\ K_j & K_1 & K_2 & \cdots & K_n \end{bmatrix} \tag{11}$$

where, $K_j = \sum_{i=1}^{n} w_i \xi_{ij}$. R_w is composite matter-element of the weight, and w_i is the weight of indicator i.

The level of the matter evaluated can be determined, according to the principle of maximum correlation, that is, $K^* = \max\{K_1, K_2, \cdots, K_n\}$.

3 Results

Improved fuzzy matter-element evaluation method (IFMEM) is used to evaluate the water quality of the Luokou mainstream estuary at the first ten weeks in 2011. The concentrations actually monitored of four indicators at ten weeks are shown in Table 3 (China National Environmental Monitoring Center, 2011). The Luokou mainstream estuary is an important monitoring section of the Yellow River, and it is in Jinan City, Shandong Province of China.

In Table 1, boundary values of pH at five levels are from 6 to 9, which have no clear boundaries. Meanwhile values of pH at ten weeks range from 8.35 to 8.63, not great differences. Thus only three indicators are taken into account, which are DO, COD and NH_3-N.

The variation coefficient method (VCM) is used to determine the weights of three indicators, according to the concentration actually monitored in Table 3. The weights calculated are shown in Table 4.

Then substitute the data in Table 3 into Eq. (6), and the membership can be calculated. Construct the matrix of fuzzy evaluation for each week, and operate correlation analysis. Thus composite fuzzy matter-elements with correlation coefficient are obtained, as are shown in Table 5. The level of the matter evaluated can be determined, according to the principle of maximum correlation.

Compare the results of improved fuzzy matter-element evaluation method (IFMEM) and the ones of traditional fuzzy evaluation method (TFEM) with the actual water

Table 3 Concentrations actually monitored of four indicators at ten weeks*

Week	pH	DO (mg/L)	COD (mg/L)	NH_3-N (mg/L)
1	8.42	11.5	2.9	0.11
2	8.44	12.7	2.0	0.14
3	8.43	12.3	2.3	0.14
4	8.35	11.8	2.3	0.34
5	8.37	12.9	2.2	0.25
6	8.35	12.7	2.3	0.26
7	8.47	11.5	2.0	0.26
8	8.63	11.7	2.3	0.31
9	8.48	9.95	1.8	0.23
10	8.46	10.9	1.8	0.29

* Data are from China National Environmental Monitoring Center, 2011.

Table 4 Weights calculated based on the variation coefficient method

Indicator	Variation coefficient	Weight
DO	3.9240	0.4461
COD	1.7316	0.1968
NH_3-N	3.1413	0.3571

quality level. Results of evaluation on water quality of two methods are shown as Table 6. In Table 6, "Official" stands for actual water qualities which were published officially (China National Environmental Monitoring Center, 2011).

Table 5 Composite fuzzy matter-elements for five water quality level for 10 weeks

Week	I	II	III	IV	V
1	0.4587	0.2771	0.0038	0.0000	0.0000
2	0.3478	0.3002	0.0058	0.0000	0.0000
3	0.3533	0.3056	0.0058	0.0000	0.0000
4	0.1411	0.4963	0.0554	0.0000	0.0000
5	0.1475	0.4537	0.0223	0.0000	0.0000
6	0.1463	0.4656	0.0249	0.0000	0.0000
7	0.1409	0.4601	0.0249	0.0000	0.0000
8	0.1415	0.4963	0.0417	0.0000	0.0000
9	0.1504	0.4230	0.0178	0.0000	0.0000
10	0.1331	0.4792	0.0342	0.0000	0.0000

Table 6 Results of water quality level

Method	Week									
	1	2	3	4	5	6	7	8	9	10
IFMEM	I	I	I	II	II	II	II	II	II	II
TFEM	I	I	I	I	I	I	I	I	I	I
Official	I	II	I	II	II	II	II	II	II	II

IFMEM: improved fuzzy matter-element evaluation method; TFEM: traditional fuzzy evaluation method; Official: China National Environmental Monitoring Center, 2011.

4 Discussions

4.1 Weights

The weights of evaluation indicators calculated by the traditional calculating superscales method (CSM)(Zhou, et al., 2009) are shown in Table 7, while weights of indicators calculated by the calculating entropies method (CEM) in Table 8.

Comparing the traditional CSM with VCM and CEM for weight determination of evaluation indicators, a big decrease of workload in the evaluation has achieved according to Tables 4, 7 and 8. In the traditional CSM, when making evaluation for water quality of more than 10 weeks, values of the above 10 weeks data have been used to too many times. One needs to calculate once at every monitoring section to get the weight of 3 evaluating indicators, totally 10 times of repeated work. However, using the VCM and CEM in determination of weight, only one calculation is made to get a set of weight suited for all the monitoring weeks compared with the traditional CSM. The CEM has been verified it can reduce the workload in determining the weights (Zou et al., 2006). The VCM achieves the same purpose as the CEM.

Table 7 Weights of indicators calculated by the calculating superscales method

Week	DO	COD	NH_3-N
1	0.7876	0.0389	0.1736
2	0.7783	0.0240	0.1977
3	0.7699	0.0282	0.2019
4	0.5875	0.0224	0.3900
5	0.6757	0.0226	0.3017
6	0.6635	0.0235	0.3130
7	0.6431	0.0219	0.3350
8	0.6065	0.0233	0.3702
9	0.6378	0.0226	0.3396
10	0.6078	0.0197	0.3726

Table 8 Weights of indicators calculated by the calculating entropies method

Indicator	Entropy	Weights
DO	0.9320	0.2077
COD	0.8463	0.4693
NH_3-N	0.8942	0.3231

While in the traditional CSM, the weights of evaluation indicators are determined by the monitoring data compared to water quality standard. As a result, when an abnormal value appears at some evaluation indicator, the condition of overestimate of weight of this indicator would lead to bad evaluation result. To the same value of monitoring section with the same indicator, the weight determined may have quite different value. For example, from Table 3 the monitoring values of DO at Week 1 and Week 4 are separately 11.5 and 11.8 mg/L which are very close, but the weights determined are separately 0.7876 and 0.5875, with a relative error of 25.41%. The error is quite serious. This is because an abnormal value of NH_3-N at Week 4, that is 0.34 mg/L, affect too much on the results. The CEM and the VCM for determination of weight both can consider adequately the useful information of values all the monitoring sections provided, and balance the relationship among numerous evaluating objects. This weakens the bad effect from some abnormal values and makes the result of evaluation more accurate and reasonable. The CEM and the VCM are very effective methods for evaluation indicators at this point.

The VCM and the CEM are compared so as to validate the effectiveness and superiority of the new VCM. The weights of VCM are close to the ones of the traditional CSM basically with some differences, while from Table 8 we can see the ones of CEM have great deviation from them. The concentration of COD in nature water is very small, and is much smaller than the boundary value of Level I in Water Quality Standards (GB3838-2002). Therefore, it has less impact on nature water quality, and should be given less weight. The value in the CEM is a great weight as is shown in Table 8, so it is not credible here. Although the CSM has much workload and repeated calculation, it uses the data adequately and fully. Thus the results of CSM are credible except the effect of abnormal values. The weights of VCM are closer to the ones of CSM, so they are suggested to be credible. However, the results of the CEM have great differences from the ones of the former two methods. The results of the CEM here are less credible than the results of the CSM and VCM.

In addition, The VCM can avoid equalization of weights distribution in theory. It gives a greater weight to the indicator which has larger variation coefficient and carries more information, and this can distinguished the weights well and avoid equalization.

4.2 Evaluation results

The results compared showed that results of water quality evaluated of IFMEM were the same as the actual water quality level except some slight differences, while the results of TFEM are not. At Week 2, official water quality is Level II, while results of IFMEM and TFEM are both Level I in Table 6. In Table 3 concentrations actually monitored of four indicators at Week 2 are all similar to the ones at Week 1 and 3, and are all higher than boundary values of Level I in Water Quality Standards in Table 1. Values of DO and COD at Week 2 are both superior to the ones at Week 1 and 3 yet. However, water quality at Week 2 is Level II, which seems unreasonable. This may be due to some other indicators which affect water quality, and they are not recorded in official statistics. Or there may be some random factors. The results of IFMEM are calculated by the data actually monitored at Week 2, so they are acceptable and IFMEM is credible.

The simulation results verify the validity of IFMEM. Results of IFMEM are significantly better than the ones of TFEM. This is mainly because in reality the situation is often non-linear, and IFMEM use normal membership functions which are nonlinear instead of traditional trapezoidal ones which are linear. Thus this is much closer to the reality. It makes the results more credible and reasonable.

Table 3 shows there are downward trend of DO and COD, while NH_3-N upward trend. Values of pH are between 8.35 and 8.63, little changes, and they are still range from 6 to 9. Maximum concentration of DO is 12.7 mg/L, while minimum 9.95 mg/L. Concentration of DO at the period of first 10 weeks are all higher than boundary value of Level I in Water Quality Standards, and DO unilateral level is Level I. The concentrations of COD in nature water are also small, and COD is gradually reducing. The concentrations are much smaller than its boundary value of Level I in Water Quality Standards. The concentration of NH_3-N gradually increases from 0.11, higher than the standard 0.15 mg/L in Water Quality Standards. It enters the range of Level II and is still increasing, but does not achieve Level III.

Water quality of Luokou mainstream estuary is dropping from Level I to Level II. It has been in close to the edge of level II, and its local water local water pollution is still increasing. The superscales indicator is NH_3-N. Evaluation results of IFMEM are basically the same as the official monitoring ones. IFMEM is an effective water quality evaluation method, and provides a new approach to evaluation of water quality.

However, the improved fuzzy matter-element method has some shortcomings. It is difficult to evaluate the water quality with the level of Inferior V, because the normal membership of Level Inferior V could not be calculated.

5 Conclusions

Fuzzy matter-element theory focuses on promotion of the transformation of things and solving fuzzy incompatibility. It is suitable for multi-factor evaluation, and reflects the impact of all indicators comprehensively and objectively. Thus it is an effective evaluation method. Improved fuzzy matter-element evaluation method is used to evaluate water quality in this study. The variation coefficient method is used to determine the weights indicators in natural water, so as to reduce the workload and avoid adverse effects from abnormal values and equalization of weights distribution. For the evaluation object with 3 indicators in 10 weeks, the traditional CSM should calculate 10 times repeat work to determine all the weights. However, using VCM just one calculation can obtain the weight set. The VCM also avoid the adverse effects from an abnormal value, and avoid a relative error of 25.41%.

Traditional trapezoidal membership functions are replaced by normal membership ones, which is closer to the reality. It was applied to evaluate the water quality of the Luokou mainstream estuary at ten weeks in 2011. Compared with traditional fuzzy comprehensive evaluation method, the results verify its validity and rationality. It can use information scientifically and comprehensively. It expands a new method for water quality evaluation, and will have great application significance in practice.

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