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Water Quality Assessment of Wenyu River with Variable Weight Cloud Model

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ABSTRACT

The water resource is an important guarantee of social and economic sustainable development. The improvement of water's ecological carbon sequestration ability is a direct response to the goal of "double carbon". Water quality directly affects its carbon sequestration capacity. So it is necessary to understand the water quality of rivers. In view of the fuzziness and uncertainty in water quality evaluation, this paper uses the cloud model to realize the qualitative to quantitative transformation of water quality in Wenyu River. By combining moment estimation theory with critic weight, AHM weight, and variable weight theory. A water quality evaluation method integrating a variable weight cloud model is constructed. And the temporal and spatial changes in water quality in Wenyu River are studied. The results show that the combined weights balance the influence of each index while retaining the advantages of subjective and objective weights. The results of the water quality evaluation are consistent with the practice, which verifies the feasibility and applicability of the method.

INTRODUCTION

Water quality evaluation is of great significance to the survival and development of human beings. On the one hand, according to the results of the water quality evaluation, the corresponding water purification work is carried out to improve water quality and protect water resources. On the other hand, water resources can be developed within an appropriate range to maximize the utilization of resources (Zhao 2017). The water environment of the Wenyu River plays an important role in the development of the north Canal basin. With the social attention to water ecological protection, research on the Wenyu River has gradually increased in recent years. Cai et al. (2019) combined the fuzzy set theory method and coefficient of variation method to assign weight to the combination of water quality indicators and studied the water quality of Wenyu River in 2018 by attribute recognition method (Cai et al. 2019). Li et al. (2021) used the comprehensive pollution index method to analyze and study the water quality status and temporal and spatial variation trend of Wenyu River in 2019 (Li et al. 2021). Guo et al. (2019) analyzed the temporal and spatial variation of the water quality of the Wenyu River from 1998 to 2017 and concluded that the water quality of Wenyu River gradually improved after deterioration, but the ammonia nitrogen index was still poor (Guo et al. 2019). The research shows that the water quality of Wenyu River is not optimistic. So it is necessary to further study the law of water quality change. Analyze the causes of poor water quality, and put forward targeted measures to improve water quality.

Currently, the commonly used water quality evaluation methods include the single-factor evaluation method, Nemerow index method, water quality identification index method, fuzzy comprehensive analysis method, artificial neural network method, etc. Different methods apply to different environmental conditions. But they all have certain limitations (You et al. 2021, Yin et al. 2008). The single-factor evaluation method takes the maximum pollution index as the evaluation standard. And the evaluation result is conservative, which is not conducive to the development of water resources. The Neme-row index method can make the pollutant value fluctuate when choosing different evaluation factors. And it can't reflect the condition of exceeding the standard of pollutants. The fuzzy comprehensive analysis method can quantify some factors with unclear boundaries that are not easy to quantify. When there are too many indicators, the algorithm of taking large and small will often cause excessive information loss. Resulting in the homogenization of evaluation results and fuzzy failure (Luo et al. 2021). The artificial neural network evaluation method has a high calculation accuracy. But it requires too much data and the results are poorly interpretable (Wang et al. 2019). Cloud models can better deal with the uncertain factors in the water environment assessment system. And many studies have confirmed the applicability of the cloud model in the field of water quality assessment. The cloud model can take into account the randomness and fuzziness of the water quality evaluation model (Li et al. 2004). Yang Wen confirmed the effectiveness and applicability of the cloud model in water quality evaluation (Yang 2013). Zhao et al. (2020) obtained accurate and stable water quality evaluation results by using the improved cloud model (Zhao et al. 2020). Kang Xiaobing obtained similar evaluation results of the cloud model with a combination of weighting and a fuzzy comprehensive evaluation method. It is proven to be scientific and feasible (Kang et al. 2019).

Weight has a great influence on the accuracy of evaluation results. So it is very important to choose a reasonable weight. At present, there are many methods to determine weight. Such as single weight is one-sided. There are partial subjective, light objective, or partial objective, light subjective defects. After that, there appeared many combination weight methods, such as linear combination weight, hybrid cross weight, genetic algorithm for combination weight, and game theory weight. Fusion weight can greatly improve the shortcomings of the single-weight method. Improve the accuracy of the weight. In this paper, the moment estimation theory is used to fuse the subjective weight and objective weight through the minimum deviation function. And then the cloud model is used to evaluate the water quality of Wenyu River.

MATERIALS AND METHODS

Study Area

Wenyu River is a water body carrying the middle water and rainwater of the sewage treatment plant along the coast. Which plays an important role in flood control and sewage discharge. At the same time, as originates in Beijing and flows through a wide range, it plays an ecological landscape role. In recent years, with the improvement of the discharge standards of sewage treatment plants, and the implementation of measures such as river bottom dredging, reclaimed water reuse, and wetland park construction (Chen et al. 2022), the water quality of Wenyu River has been greatly improved, and it reaches the water functional zone goal in many months (Beijing. gov. cn). In this paper, six areas, including Shahe Reservoir (section 1), Mafang (section 2), Lutuan Gate (section 3), Xinbao Gate (section 4), Sewage outlet (section 5), and Shaziying (section 6), are selected to set up monitoring sections. The monitoring sections' layout situation is shown in Fig. 1. And monthly sampling is carried out for each section. Liu et al. (2019) studied that the main source of river pollution was domestic sewage, and selected four water quality indexes of pH, DO, COD and NH_3-N as evaluation factors (Liu et al. 2019). Ren et al. (2021) selected three representative indicators: DO, COD and NH_3-N (Ren et al. 2021). This paper selects three water quality indexes of DO, COD, and NH_3-N to study the water quality of Wenyu River.

Research Method

In this paper, the cloud model coupled with comprehensive weight is selected to evaluate and study the water quality of Wenyu River. The comprehensive weight is formed by combining the attribute hierarchical model (AHM) and penalized variable weight as subjective weight (Yang et al. 2009). The objective weight is calculated with CRITIC, and then the moment estimation theory is used to combine subjective weight and objective weight. The variable weight theory reflects the interaction between different indexes according to the balanced function. The value of one index meeting the high standard of water quality does not mean that the water quality of the whole water body belongs to a high standard. It is necessary to select the penalty equilibrium function to calculate the variable weight through the common judgment of all indexes. The combination of penalty variable weight based on the attribute hierarchical model (AHM) can compensate for the subjective arbitrariness of humans to some extent. The moment estimation theory (Wu et al. 2022) fuses all kinds of weights according to the minimum deviation function to find the optimal combination mode and retain the advantages of all kinds of weights, avoiding the amplification effect of multiplication, addition, combination, and weight assignment methods on weights. Cloud models can better reflect the uncertainty and randomness of water quality so that the evaluation results of water quality are objective and reliable. The process of integrating the variable cloud model is shown in Fig. 2.

Determination of Weight

Weight is an important part of the evaluation system, so it is particularly important to determine an objective and reasonable weight. All kinds of indexes in water bodies interact with each other, so the penalized variable weight is integrated into the attribute analytic hierarchy process. So that the influence of each index tends to be balanced on the evaluation results of water quality. Reducing the effect of strong indexes, and enhancing the influence of weak indexes. The objective weight and subjective weight are fused together to form a combined weight-by-moment estimation theory. This not only keeps the objectivity of the critic method and the advantages of the AHM method but also avoids the multiplication phenomenon of simple linear weight fusion.

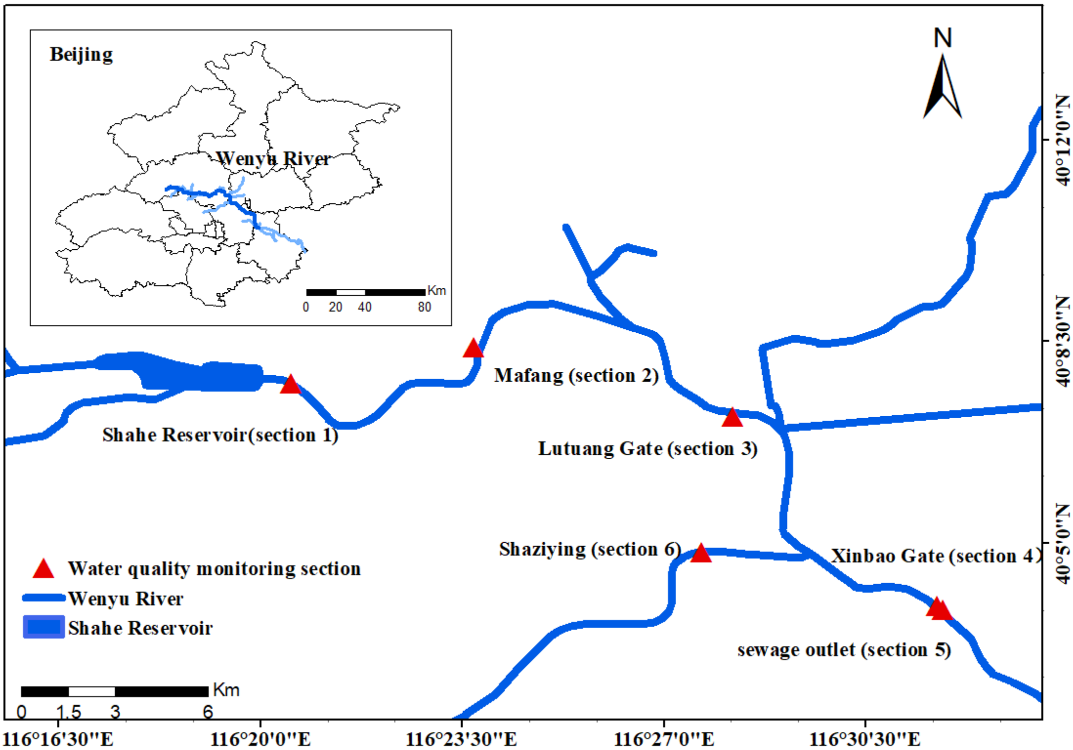

Fig. 1: Layout of monitoring section.

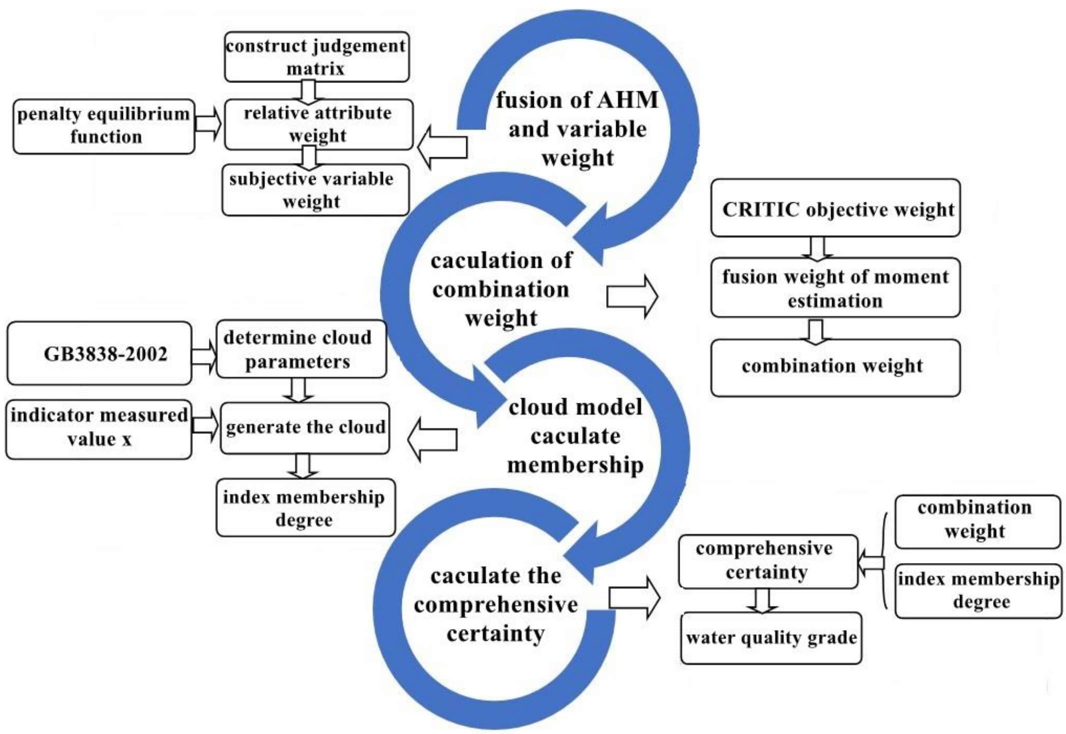

Fig. 2: Integrated evaluation system of the dynamic weight cloud model.

CRITIC Objective Weight

Diakoulaki et al. (1995) proposed the critic method to determine the objective weight. It contains the contrast intensity and conflict between different indicators in decision-making problems. And it can more comprehensively reflect the attribute information of the data itself. The standard deviation is used to represent the comparison intensity. The larger the standard deviation is, the greater the volatility is. And the larger the proportion is, the higher the correlation coefficient is. The smaller the conflict is and the smaller the weight is. The specific formula for determining the weight is as follows.

the j-th objective weight W_j is:

$$W_j = \frac{C_j}{\sum_{j=1}^{p} C_j} \quad \ldots(1)$$

$$C_j = S_j \sum_{i=1}^{p}(1 - r_{ij}) = S_j \times R_j \quad \ldots(2)$$

$$R_j = \sum_{i=1}^{p}(1 - r_{ij}) \quad \ldots(3)$$

Among them, the C_j said information, R_j says index conflict, S_j said the standard deviation of the j-th indicators.

$$S_j = \sqrt{\frac{\sum_{i=1}^{n}(Xij - Xj)^2}{n-1}} \quad \ldots(4)$$

$$X_j = \frac{1}{n\sum_{i=1}^{n} Xij} \quad \ldots(5)$$

AHM Weight of Fused Variable Weight

The attribute hierarchical model (AHM) is easier to calculate than AHP. It does not need to solve the eigenvector and eigenroot of the matrix and consistency test. It only needs a simple calculation to achieve the same effect as AHP. Each index does not exist in isolation but is interrelated. The overall water quality situation cannot be determined by the good or bad situation of one index, but the mutual influence of each index should be considered comprehensively. Therefore, the subjective weight and punishment equilibrium function are combined to form the AHM weight of the fusion variable weight theory.

Firstly, it should construct a judgment matrix A. In the evaluation index level, the target layer is set as water quality grade, and the criterion layer is DO, COD, and NH_3-N. In the criterion layer, according to the nine-scale method, the judgment matrix is obtained by comparing the importance of two elements

Secondly, it should calculate the relative attribute weight (Cheng 1997). Relative attribute B_{ij} measure the conversion formula is:

$$B_{ij} = \begin{cases} \frac{\beta K}{\beta K+1}, A_{ij} = K(i < j) \\ \frac{2}{\beta K+2}, A_{ij} = 2/K(i > j) \\ 0, A_{ij} = 0(i = j) \end{cases} \quad \ldots(6)$$

$$\beta = 1$$

Then we can get the relative attribute judgment matrix B and the relative attribute weight ω_A.

$$\omega_{Bi} = \frac{2}{m(m-1)} \sum_{j=1}^{m} B_{ij} \quad \ldots(7)$$

$$\omega_A = (\omega_{B1}, \omega_{B2}, \omega_{B3})^T$$

Thirdly, it should fuse punishment type of variable weight. In the first step, we should get the weight state vector matrix X. Then we calculate the i-th term of the penalty variable weight vector in n-dimension according to the following formula (Yang et al. 2009).

$$\omega_i(x_1, x_2, \ldots, x_n) = \frac{\frac{\omega_i}{x_i}}{\sum_{j=1}^{m} \frac{\omega_i}{x_i}} \quad \ldots(8)$$

Finally, we can get the subjective weight after the fusion.

$$\omega = \left(\omega_{DO}, \omega_{COD}, \omega_{NH_3-N}\right)^T$$

Combination Weight

Combining subjective weight and objective weight with moment estimation theory can overcome the unreasonable phenomenon of linear weighted average and multiplication normalization while retaining the influence of subjective weight and objective weight.

Use α on behalf of the subjective weight proportion, use β represents the proportion of objective weight, have a kind of subjective weight x and y kind of objective weight, m as an index number. The calculation formula (Ji et al. 2018) is as follows.

$$\begin{cases} minH(\omega_i) = \alpha_i \sum_{s=1}^{x}(\omega_i - \omega_{si})^2 + \beta_i \sum_{o=1}^{y}(\omega_i - \omega_{oi})^2 \\ s.t \quad \sum_{i=1}^{m} \omega_i = 1, 0 \le \omega_i \le 1, 1 \le i \le m \end{cases} \quad \ldots(9)$$

$$\alpha_i = \frac{E(\omega_{si})}{E(\omega_{si}) + E(\omega_{oi})} \quad \ldots(10)$$

$$\beta_i = \frac{E(\omega_{oi})}{E(\omega_{si}) + E(\omega_{oi})} \quad \ldots(11)$$

$$\alpha = \frac{\sum_{i=1}^{m} \alpha_i}{m} \quad \ldots(12)$$

$$\beta = \frac{\sum_{i=1}^{m} \beta_i}{m} \quad ...(13)$$

The Lagrange multiplier method was used to solve the above optimization model.

$$\omega_i = \left(\alpha \sum_{s=1}^{x} \omega_{si} + \beta \sum_{o=1}^{y} \omega_{oi}\right)/(x+y) -$$

$$\left(\sum_{i=1}^{m} \left(\alpha \sum_{s=1}^{x} \omega_{si} + \beta \sum_{o=1}^{y} \omega_{oi}\right) - x - y\right)/(m * (x+y))$$

$$\omega = (\omega_1, \omega_2, \omega_3) \quad ...(14)$$

Evaluation Methodology

The cloud model coupled with comprehensive weight to calculate the comprehensive determination of the combined dynamic weight and the membership degree determined by the cloud model, and obtain the water quality grade according to the principle of maximum membership degree. Normal membership cloud was first proposed by Academician Li Deyi in 1995. It reflects the fuzziness and randomness of things and can realize the transformation between qualitative concepts and quantitative values. The normal cloud model is represented by three independent characteristic numbers, which are the expectation E_x, entropy E_n and super-entropy H_e. The expectation is the most typical sample point for concept quantification. Entropy is the uncertainty of qualitative concepts. And super-entropy is the entropy of entropy, which reflects the randomness of the sample appearance of qualitative concept value and reveals the correlation between fuzziness and randomness. Many cloud droplets are generated by the forward cloud generator to form the cloud. The overall shape of the cloud model is outlined by the expectation curve, and the thickness of the cloud is determined by H_e.

Calculation of Cloud Characteristic Parameters (Lei 2019)

$$E_x = (B_{\min} + B_{\max})/2 \quad ...(15)$$

$$E_n = (B_{\max} - B_{\min})/2.355 \quad ...(16)$$

$$H_e = K\, E_n \quad ...(17)$$

Where, $B_{\max}$ and $B_{\min}$ are the total upper and lower limits of bilateral constraints of this index respectively. For the index standard with a single boundary, $B_{\max} = 2B_{\min}$ (Liu et al. 2014). K takes the empirical value 0.1. According to the surface water quality standard, it is concluded that the indexes in all three parameters of the water quality grade size are as shown in Table 1. Take cloud drop N = 2000 to draw the cloud map of each indicator level, as shown in Fig. 3.

Forward Normal Cloud Generator Algorithm Steps

(1) Generate a normal random number E_n' with E_n as expectation and H_e as a standard value.

(2) To generate an E_x as expected, the absolute value of E_n' as the standard deviation of the normal random number x.

(3) Calculate the membership of cloud droplet y corresponding to x. $y = \exp\left[-\frac{(x-Ex)^2}{2(En')^2}\right]$..

(4) Repeat n times to produce n cloud droplets to form the entire cloud.

Calculation of Comprehensive Certainty

Calculate the degree of certainty according to the steps in the b section.

Evaluation Result

The water quality evaluation level is determined according to the principle of maximum membership.

RESULTS AND DISCUSSION

The Evaluation Results

According to the water quality monitoring data of Wenyu River in 2021. The weight of each section is calculated

Table 1: Cloud parameters of each indicator standard.

		I	II	III	IV	V	VI
DO	E_x	11.25	6.75	5.50	4.00	2.50	1.00
	E_n	3.18	0.64	0.42	0.85	0.42	0.85
	H_e	0.32	0.06	0.04	0.08	0.04	0.08
COD	E_x	7.50	15.00	17.50	25.00	35.00	60.00
	E_n	6.37	0.00	2.12	4.25	4.25	16.99
	H_e	0.64	0.00	0.21	0.42	0.42	1.70
NH_3-N	E_x	0.08	0.33	0.75	1.25	1.75	3.00
	E_n	0.06	0.15	0.21	0.21	0.21	0.85
	H_e	0.01	0.01	0.02	0.02	0.02	0.08

Table 2: Objective weight of each section.

Monitoring section	DO	COD	NH_3-N
1	0.359	0.349	0.292
2	0.323	0.358	0.318
3	0.315	0.370	0.315
4	0.258	0.516	0.225
5	0.384	0.374	0.242
6	0.293	0.500	0.207

Table 3: The combined weight of each section.

Monitoring section	DO	COD	NH_3-N
1	0.311	0.363	0.326
2	0.302	0.365	0.333
3	0.300	0.368	0.332
4	0.285	0.405	0.310
5	0.317	0.369	0.313
6	0.294	0.401	0.305

as shown in Table 2 and Table 3. The objective weight is calculated by the CRITIC method and the subjective weight is calculated by a fusion of AHM and variable weight theory. The combined weight is calculated by moment estimation theory.

The subjective weight after the fusion is

$$\omega=\left(\omega_{DO},\omega_{COD},\omega_{NH_3-N}\right)^T=(0.217,0.437,0.346)^T$$

The results of calculating comprehensive certainty with different weights are shown in Table 4.

The water quality of Wenyu River in December 2021 was evaluated by using different weighted combined cloud model methods and single-factor methods. The evaluation results are shown in Table 5. According to the above steps, the combined weight cloud model is used to evaluate the water quality of six monitoring sections of Wenyu River from March to December 2021, and the results are shown in Fig. 4. The results of the single factor evaluation method are shown in Fig. 5.

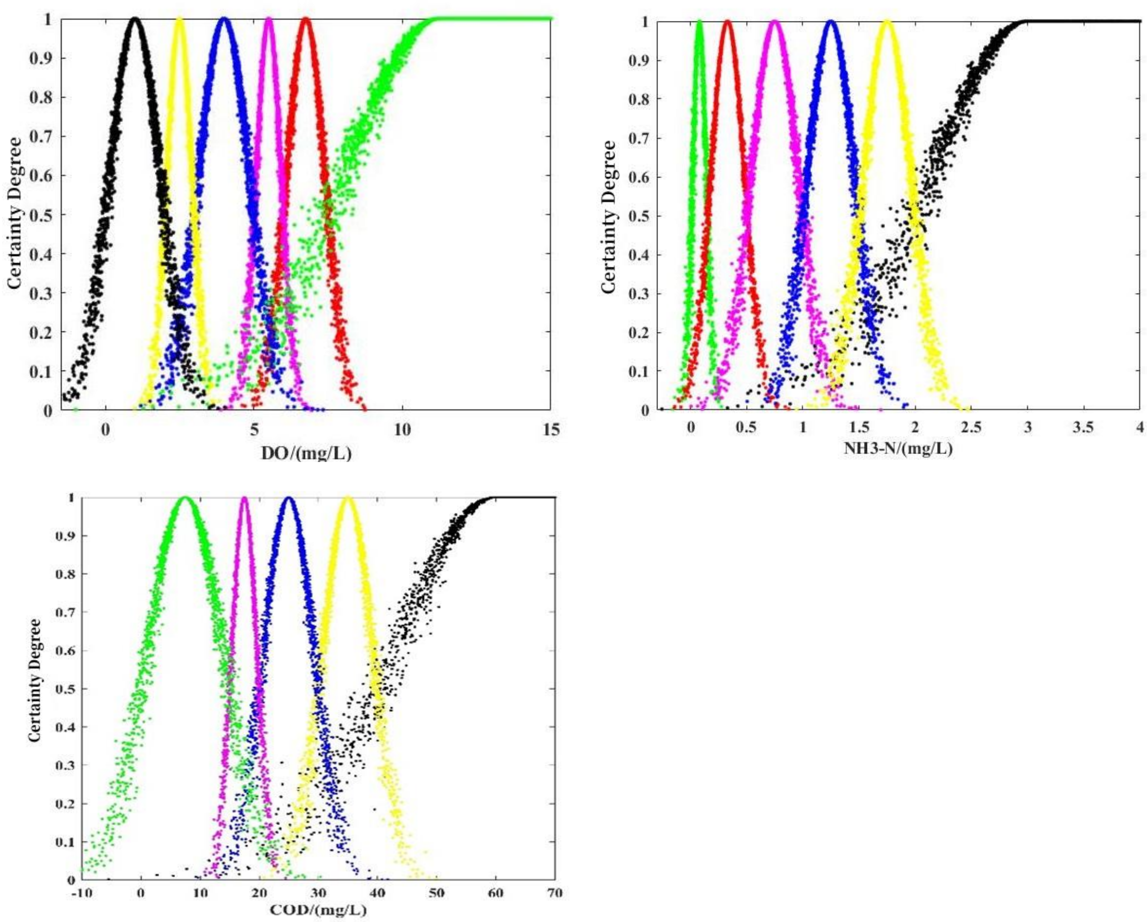

Fig. 3: Cloud view of each indicator water quality standard.

Table 4: Different weights to get comprehensive certainty of each section.

Monitoring Section	Different weight	I	II	III	IV	V	VI
1	Combined weight	0.0178	0.1302	0.2102	0.2652	0.0411	0.253
	Critic weight	0.0187	0.1092	0.1764	0.2772	0.0433	0.2833
	AHM weight	0.0185	0.1683	0.2718	0.2757	0.0411	0.1661
	Penalty variable weight	0.018	0.1634	0.2639	0.2679	0.0403	0.1834
2	Combined weight	0.2465	0.0027	0.0185	0.3536	0.0292	0.2977
	Critic weight	0.2384	0.0026	0.0165	0.3167	0.0266	0.331
	AHM weight	0.2627	0.0028	0.0234	0.4482	0.0358	0.2149
	Penalty variable weight	0.2553	0.0028	0.0227	0.4353	0.035	0.2319
3	Combined weight	0.2729	0.0003	0.0004	0.1023	0.2531	0.3876
	Critic weight	0.2589	0.0003	0.0003	0.091	0.2252	0.4315
	AHM weight	0.2926	0.0004	0.0005	0.1301	0.3217	0.2966
	Penalty variable weight	0.2844	0.0003	0.0004	0.1263	0.3125	0.3154
4	Combined weight	0.2846	0	0.02	0.333	0.0754	0.2545
	Critic weight	0.2309	0	0.0135	0.225	0.0938	0.3435
	AHM weight	0.3186	0	0.027	0.45	0.0594	0.1741
	Penalty variable weight	0.3097	0	0.0262	0.437	0.062	0.1866
5	Combined weight	0.1239	0.3469	0	0	0	0.6261
	Critic weight	0.1363	0.3817	0	0	0	0.5865
	AHM weight	0.1264	0.3539	0	0	0	0.6287
	Penalty variable weight	0.1228	0.3439	0	0	0	0.6369
6	Combined weight	0.2786	0	0	0.0003	0.1435	0.3955
	Critic weight	0.2496	0	0	0.0002	0.1211	0.428
	AHM weight	0.3033	0	0	0.0005	0.1668	0.3661
	Penalty variable weight	0.2948	0	0	0.0004	0.165	0.3736

Table 5: Water quality evaluation results of different methods.

Evaluation method	1	2	3	4	5	6
Single factor	IV	VI	VI	VI	VI	VI
Combination weight-cloud	IV	IV	VI	IV	VI	VI
Critic-cloud	VI	VI	VI	VI	VI	VI
AHM-cloud	IV	IV	V	IV	VI	VI
Penalty variable weight-cloud	IV	IV	VI	IV	VI	VI

Temporal and Spatial Variation of Water Quality in Wenyu River in 2021

In terms of time, the water quality of Wenyu River in July, August, September, and December is worse than that of other months. Water quality is relatively good in November, March, and April. That is, the water quality in flood season is worse than that in non-flood season. It may be that the erosion effect of flood season rain on the ground will bring some surface pollution into the river, resulting in increased pollution. The value of the dissolved oxygen index in all sections from June to October is significantly lower than that in other months. And the dissolved oxygen content in other months meets the class I water standard. In summer, high temperatures lead to accelerated metabolism and rapid reproduction. So the consumption of dissolved oxygen increased. And the dissolved oxygen content in water decreased. The content of the COD index from August to November is lower than that of other months. It may be that the increase of microorganisms in water consumes a lot of organic matter, leading to the reduction of COD content in water. Which is consistent with the analysis of DO.

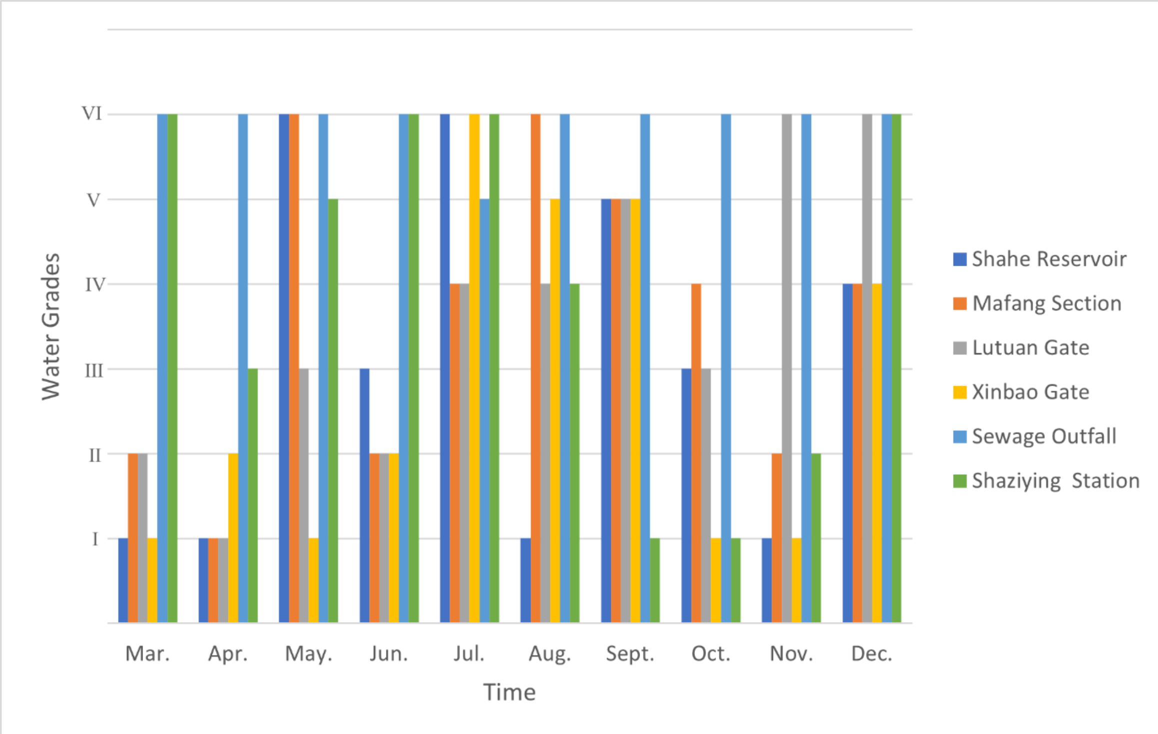

Fig. 4: Temporal and spatial variation of the combined weight cloud model of water quality in Wenyu River in 2021.

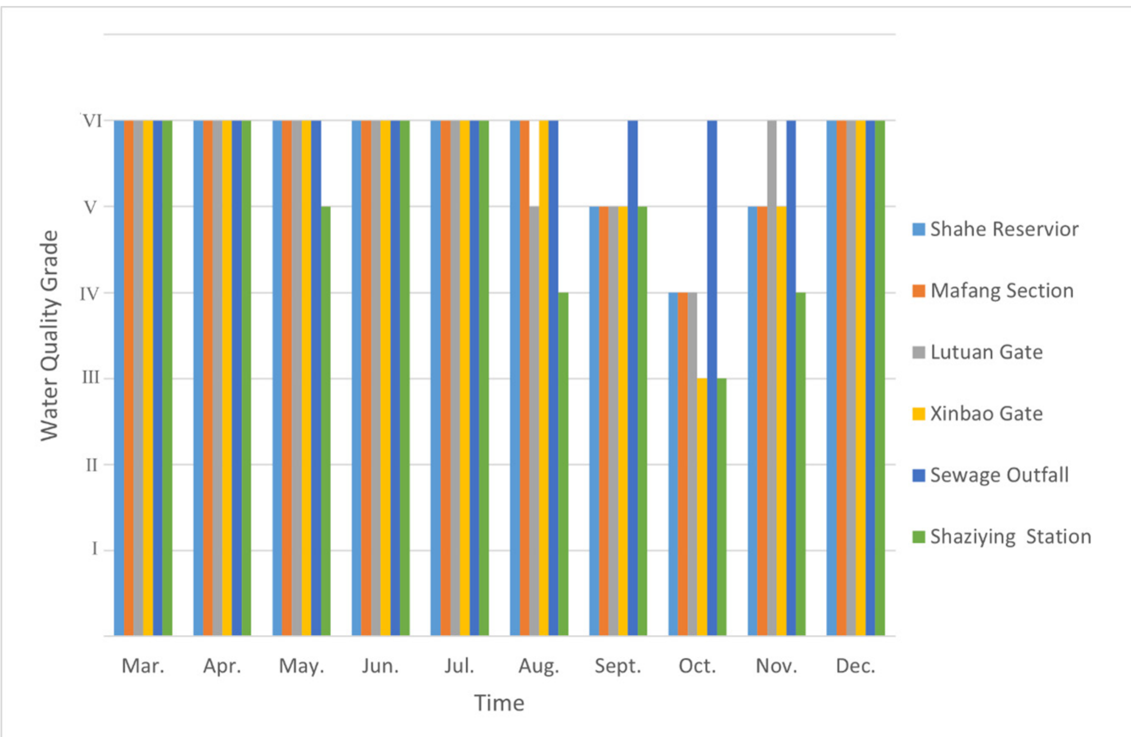

Fig. 5: Temporal and spatial changes of single-factor assessment method for water quality of Wenyu River in 2021.

Ammonia nitrogen indexes in May and July to September were worse than in other months. The reason may be that more nitrogen is washed into the river from the ground near the shore. Increases the amount of nitrogen in the water. Biological organic nitrogen produces ammonia nitrogen by consuming dissolved oxygen through ammonification. Thus the ammonia nitrogen content increases, and the dissolved oxygen content decreases. The reason for the decrease in dissolved oxygen in this period was further verified.

From the spatial dimension, the water quality of the sewage outlet section is the worst, all of which is inferior V water. The second is the sand camp section, with 5 months of water quality V and below; There were 6 months in the Mafang section with category IV water and below. 5 months of Lutuan gate section are IV type water and below. 4 months of the Shahe reservoir section and Xinbao section were classified as IV-type water or below. Except for August, September, and October, the COD of the sewage outlet section is in the standard of inferior V water, and the ammonia nitrogen is in the standard of VI water in all months. In a few months, the proportion of ammonia nitrogen exceeds the standard by more than 8 times. And COD exceeds the standard by more than three times. So it is inferred that there is still a direct discharge of wastewater in this section.

Cloud model the cloud map of various water quality standards is close to a normal distribution. When the index exceeds the standard seriously, that is, when the measured value X deviates far from the standard of each class. It is often reflected in the positive index greater than the I class water standard and the condition of the negative index is far less than the water V class standard. The membership degree of the cloud model will be full is 0. Then embodied in the index did not affect the results of the water quality evaluation. The evaluation result is too ideal. Especially when fewer indicators are selected, the impact on the results can even be decisive. Which is not in accordance with the actual situation. Therefore, when an index seriously exceeds the standard of class V water, the membership degree of inferior class V water of the index is given a number close to 1 from the left. Which can avoid the evaluation result error caused by the above situation.

Comparison of Evaluation Results of Combined Weight and Other Single-Weight Combined Cloud Models

The results of the single-factor evaluation method show that the water quality of Wenyu River in December 2021 is inferior V class. Because the single factor takes the worst index as the basis of water quality evaluation. And the COD value of each monitoring section exceeds the standard of V-class water, so all is inferior V-class water. The evaluation result obtained by the objective weight critic method is also poor V. CRITIC method to determine the weight of objective data. in the three indicators, the weight of COD is relatively large, and COD seriously exceeds the V class water standard, so the impact of water quality evaluation results is relatively large. The evaluation result of AHM is the best. Which is greatly influenced by personal subjectivity. Because COD water quality is too bad. If a large weight is given, all the evaluation results of water quality will be poor V. So DO and ammonia nitrogen are given relatively large weights. Except for the section on sewage outlet, the value of ammonia nitrogen in December is basically around the class III water standard, so the evaluation result is more optimistic than other methods. The evaluation result of combination weight is consistent with that of penalty variable weight. The evaluation result is better than that of the single factor evaluation method and critic objective weight. But worse than that of AHM subjective weight. The moment estimation theory fuses subjective weight and objective weight through the minimum deviation function. So that the combined weight tends to be between them.

According to the single-factor evaluation method, the indexes that have a bad influence on water quality can be obtained. The results of water quality evaluation based on the worst indexes are conservative. Which cannot fully reflect the water quality of rivers and restrict the development and utilization of rivers. AHM is greatly influenced by personal subjectivity and lacks the support of objective data, so it cannot objectively reflect the water quality situation. The variable weight attribute hierarchical model is to adjust the weight of indicators according to the changes in index values to ensure some balance among indicators. For the water quality evaluation system, the relative importance of each index can be reflected more accurately by considering the mutual influence of each index. Moment estimation theory integrates variable weight attribute analytic hierarchy process and criticism. And combines the artificial experience of subjective weight with the reality of objective weight.

CONCLUSIONS

1. Compared with single empowerment, the combined variable Kwon model can reflect the status of water quality of the real objective. And considering the interaction between the various indicators. A blend of human experience and objective data. Then the combination weights are more reasonable. the uncertainty of the cloud model to the water quality by the mapping of the quantitative representation method.

Let the water quality situation be more specific and intuitive.

2. According to the water quality measurement of Wenyu River in 2021, the indexes are closely related. This is reflected in the increase of organic nitrogen content in water from July to October due to rainfall erosion. Then the ammonia nitrogen content is increased by ammonification. After ammonification, ammonia nitrogen content increases, and plants can absorb ammonia nitrogen and COD as nutrients for their growth. Then COD goes down, the whole process consumes oxygen, so the dissolved oxygen in the water goes down.
3. From the perspective of spatial distribution, the water quality of six monitoring sections of Wenyu River in 2021 is as follows: Xinbao gate > Shahe reservoir> Mafang > Lutuan gate > Shaziying section > sewage outlet. The sewage outlet section is the most seriously polluted. Because COD and ammonia nitrogen seriously exceed the standard of poor V water, the water quality in 2021 is poor V. In terms of time distribution, the water quality in flood season was worse than that in non-flood season.
4. The determination of entropy and super entropy in the characteristic parameters of the cloud model needs further study. And for the standard indexes with no upper or lower bounds in GB 3838-2002, such as the water standard of DO. There is no upper limit. And the determination of boundaries also needs further study. There is no specific standard for water quality grade in GB 3838-2002, for example, pH is 6-9 in class I to V water. And turbidity has no corresponding standard. The calculation of these indicators needs to be studied.

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