Research on the Purification Effect of Aquatic Plants Based on Grey Clustering Method

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Abstract. This paper uses the grey clustering method to evaluate the water quality level of the MingGuan constructed wetland at the import and export of artificial wetlands. Constructed wetland of Ming Guan is established on the basis of the Fuyang River’s water quality improvement, to choose suitable aquatic plants, in order to achieve the Fuyang River water purification effect. Namely TP, TN, NH₃-N, DO, COD and Permanganate index are selected as clustering indicators. Water quality is divided into five grades according to the Surface Water Environmental Quality Standard (GB3838-2002) as the evaluation standard. In order to select the suitable wetland plants, the purification effect of 6 kinds of higher aquatic plants on the sewage of Fuyang river was tested. One kind of plants was selected: Typha. The results show that the water quality of the section is gradually changed from V water quality to III water quality. After artificial wetland of cycle for a long time, Typha has good purification effect. In November, water quality categories are basically concentrated in the VI, V class, may be caused by chemical decomposition of aquatic plants, should strengthen the academic research.

Keywords: Hydrophyte; Gray clustering; Purifying effect

1. Introduction
The Fuyang River is important industrial and agricultural water in Handan area, which is a backbone river of drainage, flood control, irrigation and shipping. However, through the observation of monitoring data in recent years to Fuyang, we found Fuyang River water quality monitoring categories are mostly V or super V class [1], which has seriously affected urban residents, industry and agriculture.

Therefore, it is imperative to clean up the Fuyang River. On the basis of Handan city industrial and agricultural development and the development trend of urbanization, grasp the present water pollution in Fuyang River, using water ecosystem purification technical route, establish a comprehensive and effective prevention and control measures. In order to achieve this initiative we establish the Ming Guan artificial wetland [2] simulation and comb with the grey clustering evaluation of water quality model to select the suitable aquatic plant, so that meet the FuYang river water quality purification effect.

2. Evaluation Method

2.1. Monitoring Points and Monitoring Results.
In the Mingqing artificial wetland test field, seven monitoring points are set up to observe the changes of different aquatic plants and the change of water quality. The monitoring point at the inlet is 1, which was the inlet of the Fuyang River in Handan. 6, 7 two monitoring points are to study the point of the
article, followed by entry points and exit points of typha. The water quality evaluation of this article uses the monitoring data of the import and export of the monitoring points. The monitoring of water quality is TP, TN, NH3-N, DO, COD and COMMn. Monitoring frequency is once two weeks and the specific time is every two weeks on Monday. The monitoring results are shown in Tables 1.

| Measure time | TP  | TN  | NH3-N | DO   | COD | COM Mn |
|--------------|-----|-----|-------|------|-----|--------|
| 2016.10.04   | 0.08| 3.4 | 1.62  | 7.59 | 12  | 5.81   |
| import       |     |     |       |      |     |        |
| export       | 0.12| 3.31| 1.78  | 7.33 | 0   | 5.31   |
| import       | 0.03| 2.9 | 0.35  | 7.85 | 8   | 5.25   |
| import       |     |     |       |      |     |        |
| 2016.10.11   | 0.03| 2.45| 0.52  | 7.88 | 12  | 4.1    |
| export       | 0.04| 2.38| 0.53  | 8.46 | 24  | 5.26   |
| 2016.10.18   |     | 2.87| 0.46  | 8.01 | 8   | 5.26   |
| import       | 0.02| 0.83| 0.3   | 8.31 | 16  | 3.97   |
| import       |     |     |       |      |     |        |
| 2016.10.25   | 0.02| 1.62| 0.28  | 8.75 | 16  | 3.97   |
| export       | 0.03| 5.87| 1.49  | 8.73 | 4   | 5.99   |
| import       |     |     |       |      |     |        |
| 2016.11.02   | 0.02| 7.76| 0.65  | 8.37 | 12  | 6.34   |
| import       | 0.04| 4.01| 0.39  | 8.9  | 16  | 4.24   |
| export       | 0.05| 4.84| 0.36  | 8.2  | 8   | 4.08   |

2.2. Gray Clustering Water Quality Evaluation Model.
In 1982, Professor Deng Julong, a Chinese scholar, proposed a gray system theory. He elaborates that clustering analysis is a multivariate statistical method, which classifies research objects according to the nature of affection relation so as to be able to reflect the intrinsic combination relationship between samples, and objectively and truly reflect the systematic analysis method of system essence. In the clustering analysis, the whitening function of gray theory is introduced to form the gray clustering [3-4]. Gray clustering is the whitening number of the clustering objects to different clustering indexes, To determine which class the cluster belongs to. Therefore, it is suitable for wetland water quality evaluation.

It is envisaged that there is a clustering object (measurement point), and each cluster object has an indicator (pollutant), each indicator has a gray class (environmental quality level), according to the first ([1,2,...,m]) Objects on the ([1,2,...,n]) sample of the sample value \(C_{ki}\) will be the first k objects into the first class of gray, called gray clustering. Gray clustering water quality evaluation model [5]. The general form is as follows: ① to determine the composition of clusters and indicators; ② data dimensionless treatment; ③ the establishment of the albino function of pollutants; ④ calculate the clustering of the indicators; Determine the clustering coefficient, and according to the clustering coefficient of water quality evaluation conclusions, so as to determine the sample water quality level.

2.3. Determine the Composition of the Sample and Evaluation Indicators.
The water quality monitoring data of the entrance and exit of wetland in typha area are selected. Evaluation indicators are respectively total phosphorus (TP), total nitrogen (TN), ammonia (NH3-N), dissolved oxygen (DO), chemical oxygen demand (COD) permanganate index (COMMn). The
evaluation criteria are selected as the "Environmental Quality Standard for Surface Water" (GB3838-2002). According to the evaluation criteria, the water quality is divided into I, II, III, IV, V 5 grades. The standard values for the indicators are shown in Table 2.

| Evaluation index | I    | II   | III  | IV   | V    |
|------------------|------|------|------|------|------|
| TP               | 0.02 | 0.1  | 0.2  | 0.3  | 0.4  |
| TN               | 0.2  | 0.5  | 1    | 1.5  | 2    |
| NH3-N            | 0.15 | 0.5  | 1    | 1.5  | 2    |
| DO               | 7.5  | 6    | 5    | 3    | 2    |
| COD              | 15   | 15   | 20   | 30   | 40   |
| CODMn            | 2    | 4    | 6    | 10   | 15   |

2.4. Data is Dimensionless.
In the water quality evaluation, in order to prevent the different units of the clustering indicators and the large absolute difference, we dimensionless the whitening values (pollutant concentration) and gray matter of each index of water quality clustering samples, the clustering results with Comparability, So that the clustering results are comparable.

(1) Sample dimensionless processing
Standardization of whitening values of sample indices is carried out using the average standard value method. The formula is:

\[ d_{ki} = \frac{c_{ki}}{c_{0i}} \]

\( d_{ki} \) — The normalized value of the ith index of the kth sample;
\( c_{ki} \) — The standard measured value of the ith index of the kth sample;
\( c_{0i} \) — The reference standard of the ith index,

(2) Grayclass dimensionless processing
In order to analyze the convenient comparison between the original sample and the gray class and to Create conditions for the establishment of the whitening function, so we still use \( c_{0i} \) for the standard value of the dimensionless.

\[ r_{ij} = \frac{S_{ij}}{c_{0i}} \]

\( r_{ij} \) — The standardized treatment of the jth gray class value sij of the ith index;
\( S_{ij} \) — Gray value.

(3) Determine the whitening function
Whitening function is the reflection of clustering index on grey relation, which is not only the basis of grey clustering, but also the basis of calculating clustering coefficient.
The whitening function of the grey class i and grey j of the ith index are respectively:
The weight of each index to a grey class is called clustering weight. The weight value of the \( j \) grey index of the \( i \) index is expressed by the formula:

\[
\omega_{ij} = \frac{r_{ij}}{\sum_{j=1}^{n} r_{ij}} \quad i \in \text{错误!未找到引用源。} , j \in \text{错误!未找到引用源。}
\]  

(6)

(5) Determination of clustering coefficient and water quality grade

On the basis of determining the whitening function and clustering weight, the clustering coefficient is calculated. The clustering coefficient reflects the degree of the relationship of grey clustering samples, which is calculated as follows:

\[
\mathcal{E}_{ki} = \sum_{i=1}^{n} f_{ij}(d_{ki})\omega_{ij} \quad k \in \text{错误!未找到引用源。}
\]  

(7)

When the water quality level is determined, the pollution level is generally evaluated according to the degree of the membership value of the environmental pollution level. However, the principle of maximum membership is not applicable, which makes this method of judgment inaccuracy in some degree. Chen shou-yu proposed that the level characteristic value [6-7] should be used as the judgment standard to resolve the inapplicability of the principle of maximum membership. Set the state of the left pole to number 1, and the intermediate state from left to right is denoted as 2, 3... Until the right pole state is marked with ordinal C. 1, 2... C is called the state point and is represented by the state variable \( H \), \( h=1,2,...,c \). The level eigenvalues are calculated using the following formula:

\[
H = \sum_{h=1}^{c} \tilde{H}_h \mathcal{E}_{ki}
\]  

(8)

3. Application

The grey clustering water quality evaluation model was used to evaluate the water quality of one kind of aquatic plants imported and exported from typha in Ming Guan artificial wetland. The article takes II water quality as a reference standard, uses the formula (1) to treat table 1 and table 2 with...
dimensionless processing. Then the clustering weight is obtained by using the formulas. Last, the cluster coefficient of each index and the rank characteristic value H are listed below.

Table 3. Typha area clustering coefficient.

| measure time | I  | II | III | VI | V  | H  | water quality |
|--------------|----|----|-----|----|----|----|---------------|
| 2016.10.04   | 0.46 | 0.09 | 0.14 | 0.22 | 0.47 | 4.31 | VI            |
|              | 0.41 | 0.15 | 0.15 | 0.13 | 0.6  | 4.65 | V             |
| 2016.10.11   | 0.48 | 0.11 | 0.1  | 0    | 0.38 | 2.9  | III           |
|              | 0.47 | 0.21 | 0.02 | 0    | 0.38 | 2.84 | III           |
| 2016.10.18   | 0.33 | 0.16 | 0.22 | 0.1  | 0.38 | 3.61 | VI            |
|              | 0.47 | 0.15 | 0.1  | 0    | 0.38 | 2.98 | III           |
| 2016.10.25   | 0.36 | 0.19 | 0.3  | 0    | 0    | 1.63 | II            |
|              | 0.36 | 0.25 | 0.04 | 0.22 | 0.09 | 2.31 | II            |
| 2016.11.02   | 0.47 | 0.02 | 0.16 | 0.28 | 0.38 | 4.03 | VI            |
|              | 0.47 | 0.08 | 0.2  | 0.02 | 0.38 | 3.23 | III           |
| 2016.11.09   | 0.34 | 0.3  | 0.06 | 0    | 0.38 | 3.01 | III           |
|              | 0.47 | 0.2  | 0.01 | 0    | 0.38 | 2.8  | III           |

4. Conclusions
Using the gray clustering evaluation model, not only consider the level of water quality monitoring, water quality and water quality standard of gray, but also to consider the principle of maximum compatibility, introducing the level characteristic value to replace the maximum principle. For the single biggest principle, it is difficult to distinguish if the water quality belongs to the previous level or the next level when the evaluation results are at the same level. However, the size of the level eigenvalue can be good to distinguish the water quality level. Therefore, the application of the model to Ming Guan of aquatic plants in artificial wetland for water quality assessment can more accurately reflect the change of the import and export water quality status. The artificial wetland of Ming Guan water quality evaluation results show that typha section long time cycle, water purification condition gradually transformed into good. The water quality of the typha areas in November is significantly different from that of the water, which may be due to the change of climate temperature and the decomposition of the aquatic plant itself causes the secondary pollution of water. Therefore, the study on the impact of aquatic plant decomposition on water quality should be further strengthened.

The research proves that typha can fully adapt to the water quality of Fuyang River and purify the water quality in a short period of time. In addition, it has a very important role in environmental beautification and ecological environment protection, which is conducive to the cultivation and management and the wide range of promotion and application.

5. Acknowledgements
This work was financially supported by the research center of water ecological civilization and social governance in Hebei province. (16273604D)

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