

Selection of Health Evaluation Indexes and Standards Analysis for Water-purifying Constructed Wetland

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Abstract: According to the construction requirements and structural characteristics of the water-purifying constructed wetland in Qiangwei Lake, this research clarifies the connotation of the constructed wetland's health, and analyzes the relevant factors affecting the operation effect of the wetland. Meanwhile, based on the principle of wetland health evaluation, this research applies the analytic hierarchy process to divide the health evaluation system of the water-purifying constructed wetland in Qiangwei Lake into the goal layer, the criterion layer, and the index layer. Furthermore, by selecting a host of evaluation indexes, encompassing water quality indexes, wetland structure, biodiversity, etc., this research discusses and establishes the corresponding index evaluation standard, ultimately constructing the comprehensive scoring system of the wetland.

1. Introduction

Wetland, as one of the three major ecosystems on the earth, is crucial to human survival and global sustainable development^[1]. Likewise, it is of paramount significance to construct a wetland health evaluation system to effectively evaluate the health status of the wetland ecosystem for mastering the overall operation status of the wetland as well as evaluating the treatment effect of the wetland. Admittedly, the evaluation of wetland ecosystem health is a complex issue, which has a certain relationship with the classification of wetlands. As a whole, wetlands can be classified into natural wetlands and constructed wetlands. Based on the actual situation in China, as well as the *Convention on Wetlands of International Importance Especially as Waterfowl Habitat*, wetlands are divided into five categories covering 28 types, including river wetlands^[2], lake wetlands^{[3] - [4]}, mangrove wetlands^[5], and plateau wetlands^[6], etc. As the case stands, different wetland types reflect certain differences in the selection of evaluation indexes and standards. Apart from the abovementioned indexes, the selection of health evaluation indexes of constructed wetlands also highly values the functional attributes of wetlands^[7], such as water quality purification function and operation management level.

With the water-purifying constructed wetland ecosystem of Qiangwei Lake as the research object, this paper systematically discusses the index selection and standards for wetland ecosystem health evaluation, ultimately constructing an evaluation system suitable for the wetland.

2. Characteristics of the Constructed Wetland in Qiangwei Lake

The water-purifying constructed wetland of Qiangwei Lake consists of a pretreatment area, a compound surface flow wetland purification area, a submerged plant purification area, and a deep purification area, with a total area of approximately 4,402 mu, as shown in Figure 1. The combined effect of the foregoing four functional areas can realize the water purification of Qiangwei Lake and exert the function of water storage to continuously and stably ensure the safe water supply demand of Lianyungang City.

2.1 Connotation of Water-purifying Wetland Health

Water-purifying constructed wetland embodies the general characteristics of constructed wetland, which can be summarized as removing pollutants through artificial regulation of wetland operation state as well as utilization of wetland structure and the joint action of animals, plants, and microorganisms, in an attempt to achieve the goal of water purification. Nevertheless, the water-purifying constructed wetland is still different from the general constructed wetland. In particular, given its stronger functional orientation and service-based objectives, it is imperative to adopt long-term powerful artificial control measures and continuously monitor the operation status of wetlands to achieve the original design objectives.

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3. Selection of Health Evaluation Indexes for Water-purifying Constructed Wetland in Qiangwei Lake

3.1 Selection Basis of Indexes

The water-purifying constructed wetland in Qiangwei Lake can be classified as the lake wetland in the constructed wetland. For this reason, the selection of evaluation indexes not only refers to the general indexes of lake-based constructed wetlands but also incorporates corresponding characteristic indexes according to the actual construction characteristics. In short, this research will construct the health evaluation system of the water-purifying constructed wetland in Qiangwei Lake from three aspects including wetland ecological characteristics, wetland function, and economic and social function.

3.2 Selection Principles

Based on the actual operation situation and existing data concerning the water-purifying constructed wetland in Qiangwei Lake, the selection of health evaluation indexes follows the principles of systematicness, representativeness, comparability, practicality, and operability.

3.3 Construction of Index System

In accordance with the aforesaid principles, as well as the characteristics of the water-purifying constructed wetland in Qiangwei Lake, this research applies the analytic hierarchy process to divide the health evaluation of the wetland into the goal layer, the criterion layer, and the index layer. In detail, first and foremost, the goal layer aims to reflect the overall health status and operation of the wetland. Secondly, regarding the criterion layer, in line with the overall requirements of the construction goal and

operation of the constructed wetland in Qiangwei Lake, this research sets up three criterion layers, encompassing wetland ecological characteristics indexes, functional indexes, and economic and social indexes. Last but not least, the index layer aims to reflect the factor indexes of the evaluation of each criterion layer. In this regard, this research sets the corresponding evaluation standards and uses the available quantitative or qualitative judgment criteria to evaluate the health level of a certain characteristic of the wetland.

3.4 Selection of Evaluation Indexes

3.4.1 Integration of Wetland Functions

(1) Water supply assurance rate: the deep purification area in the water-purifying constructed wetland in Qiangwei Lake not only has the function of degrading pollutants but also can store purified water up to standard. Ensuring that the water supply reaches the standard during operation is an important index for evaluating the function of the wetland.

Evaluation method: conceptually, the water supply assurance degree is defined as the assurance degree of water quantity of all water supply projects by rivers with water supply functions. The water supply assurance degree is equal to the percentage of days in a year when the daily water level or flow of the river reaches the assured water level or flow of water supply to the total number of days in the year, which is calculated according to Formula (1). The comparison of scores of the index numerical results is shown in Table 1.

$$R_{gs} = \frac{D_0}{D_n} \times 100\% \tag{1}$$

Where: R_{gs} represents the water supply assurance degree; D_0 indicates the number of days when the water level or flow reaches the water supply level or flow; and, D_n denotes the total number of days in the year.

Table1 Comparison of Scores of Water Supply Assurance Rate

Water supply assurance rate	[95%, 100%]	[85%, 95%)	[60%, 85%)	[0%, 60%)
Comparison scores	100	[85, 100)	[60, 85)	[0, 60)

(2) Water quality purification function: the water purification function of a wetland (i.e., the self-purification function of a wetland) is defined as the ability of wetland ecosystem to absorb, transform, and redistribute pollutants (i.e., eutrophic substances such as nitrogen and phosphorus) in water body through its natural ecological process and material circulation to purify water body.

Evaluation method: different from the water quality indexes, the water quality purification function focuses on the removal efficiency of pollutants by the water-purifying constructed wetland in Qiangwei Lake, mainly inspecting the removal efficiency of conventional pollutants, such as CODMn, ammonia nitrogen, TP, TN, SS, and other indexes. The scores of the water quality purification function are shown in Table 2.

Table2 Comparison of Scores of Water Quality Purification Function

Items	Scoring rules			
Scores	[90, 100]	[75, 90)	[60, 75)	[0, 60)
Average removal rate of pollutants	Powerful purification function, which can cope with different pollution fluctuations and	Relatively powerful purification function, which can cope with a	General purification function, with individual indicators	Poor purification function or basically no

realize the high-efficiency removal of pollutants.	certain degree of pollution fluctuation and realize the effective removal of pollutants.	incapable of reaching the standard of Class III water in a short time.	purification function.
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(3) Habitat function: the water-purifying constructed wetland in Qiangwei Lake endows bird species with a good habitat, which not only enriches the species diversity but also plays a vital role in energy flow and maintaining the stability of the ecosystem (see Table 3 for details).

Table3 Comparison of Scores of Habitat Function

Items	Scoring rules			
Scores	[90, 100]	[75, 90)	[60, 75)	[0, 60)
Habitat function	The species and quantity of wetland animals increase significantly.	The species and quantity of wetland animals increase to a limited extent.	The species and quantity of wetland animals remain basically unchanged.	The species and quantity of wetland animals decrease.

3.4.2 Economic and Social Indexes

(1) Operation funds and management: during the operation of constructed wetlands, funds and management act as extremely important influencing factors. In this process, it is necessary to monitor the water quality over a long period. Moreover, a range of issues such as regular harvesting and replanting of plants need the support of funds and management teams. As such, relevant

evaluation indexes are established as operation and management funds, management team and level.

Evaluation method: a qualitative evaluation is conducted according to the fund reserve as well as equipment management and maintenance, with the specific evaluation criteria shown in Table 4.

Table 4 Comparison of Scores of Operation Funds and Management

Items	Scoring rules			
Scores	[90, 100]	[75, 90)	[60, 75)	[0, 60)
Management team and level	It means sufficient funds, which can ensure the maintenance and replacement of equipment, as well as salaries of management personnel.	It means relatively sufficient funds, which can ensure maintenance and salaries of management personnel.	It means that the funds can basically be used for equipment maintenance and salaries of management personnel.	It means that fewer funds make it difficult to maintain the equipment and slow down the salaries payment of management personnel.

(2) Science popularization education: constructed wetlands can also provide research objects, materials, and experimental bases for education and scientific research,

and therefore play an important role in the field of education and scientific research. The specific evaluation is shown in Table 5.

Table5 Comparison of Scores of Science Popularization Education

Items	Scoring rules			
Scores	[90, 100]	[75, 90)	[60, 75)	[0, 60)
Science popularization education	It represents high scientific research value, which leads to a certain amount of literature publication and more awards.	It represents relatively high scientific research value, which leads to some literature publications and a small number of awards.	It represents general scientific research value, which leads to few literature publications and almost no awards.	It represents low scientific research value, which leads to no literature publication and awards.

4. Conclusion

To sum up, the research on wetland health, as a complex system, involves the research fields related to diversified

sciences, as well as the testing of numerous indicators. In addition, the selection of wetland health indexes reflects both generality and particularity. Hence, it is necessary to circumspectly select relevant indexes based on an in-depth discussion on it. Given the rarity of indexes selection of

water-purifying constructed wetlands, as well as the lack of unified standard regarding construction and evaluation methods of related index systems, it is still limited by practical experience and subjective consciousness to a great extent.

In the follow-up research on the selection of evaluation indexes of constructed wetlands, it is imperative to make a qualitative analysis of wetlands from the perspective of their nature, and then seek relevant evaluation indexes and consult valuable literature experience. In this connection, while meeting the objective needs of wetland health evaluation, the selection of indexes must be able to accurately and intuitively reflect the state of wetlands. From a long-term perspective, the use of wetlands for water purification in water sources shows great development prospects. In other terms, if a general wetland health index system can be established to reflect the wetland status and management problems, it will provide solid theoretical support and promising practical application prospects for the development and application of this wetland.

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