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Health Assessment of River Ecosystems Based on Planktonic Bacteria Biointegrity Index

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Abstract: Since ancient times, river ecosystems, as the birthplace of human civilization, have played a pivotal role in human development. The purpose of this work is to study the typical physical and chemical indicators of water quality, planktonic bacteria and riparian zone conditions for river ecosystem health assessment based on planktonic bacteria biological integrity index, with basin A as the main research object. Different waters of the river ecosystem were investigated. The water quality and biological evaluation of the river ecosystem was carried out, and the health evaluation index system and model system of the river water ecosystem based on the bio-integrity index of planktonic bacteria were determined. Plankton Integrity Index (P-IBI) values are used to assess the health of river aquatic ecosystems. In 5 follow-up ratings, health is 2x. Through the correlation analysis of the water P-IBI scores calculated by the three-point method, the four-point method and the ratio method, the correlation between the results obtained by the ratio method and the four-point method is r = 0.8145, so the quartile method and The ratio method is suitable for evaluating the water ecological health of river waters.

1. Introduction

River ecosystems play a vital role in human development, not only providing abundant freshwater resources and food for human life, but also having ecological and social functions at the spiritual level. In recent years, with the rapid development of my country's industrialization and urbanization, the indiscriminate use of water resources, deforestation, and vegetation destruction have occurred frequently, especially the poor public awareness of environmental protection and lack of awareness of water resources such as rivers. Decline in the health of aquatic ecosystems [1]. Therefore, taking appropriate methods to evaluate the health of the river water ecosystem can not only understand the current state of the river, judge the degree of human activities' disturbance to the river water ecosystem, but also provide a scientific basis for decision makers to formulate river management policies [2].

In recent years, great progress has been made in river management in ecological restoration, pollution control and daily management. The Romero I C study features a decade-decadal assessment of polycyclic aromatic hydrocarbons (PAHs) in muscle tissue of Mesozoic fish species as indicators of environmental health in deep-sea ecosystems in the Gulf of Mexico (GoM). Mesophytic fish were collected before the Deepwater Horizon (DWH) oil spill (2007), immediately after the spill (2010), 1 year after the spill (2011) and 5-6 years after the spill (2015-2016) for assessment if the Mesozoic The system was exposed to and retained PAH compounds from the DWH spill. The results showed that compared with 2007 (630+/-236ng/g), PAHs in fish tissue increased 7 to 10 times in 2010-2011 (4972+/-1477ng/g). During 2015-2016, PAH concentrations declined, approaching the levels measured in the 2007 sample (827+/-138ng/g); however, the composition of PAHs remained similar to a diagenetic source, similar to those collected in 2010-2011 Sample [3]. Ogbeide O assessed the ecological and human health risks associated with residual concentrations of organochlorine pesticide residues in the Ikpoba River, a major river in the heart of the Nigerian town of Benin, in Edo State. Standard methods were used to collect, extract and analyze samples, while using standard models and indicators for risk assessment. The results showed that the pesticide concentrations in sediment and water samples varied, with α-HCH (0.24 ± 0.11 μg L-l) predominant in water, while dieldrin (0.99 ± 0.33 μg kg-l) was the highest concentration in sediment. Compared with the Sediment Quality Guidelines (SQGs), the concentrations of pesticides in the sediments of this study are lower than the medium impact range, low impact range, probable impact level and threshold impact level, indicating lower environmental hazards to benthic organisms [4]. During the years of research and application of river ecosystem health assessment, many scholars have developed many different methods.

This paper studies the health evaluation of river ecosystems based on the bio-integrity index of bacterioplankton. Taking the A river basin as the main research object, the water quality evaluation and biological evaluation of the river ecosystem are carried out respectively, and the river water ecosystem based on the bacterioplankton bio-integrity index is determined. Health evaluation index system and standard system. At present, river research mainly focuses on a single river, and the selection of indicators is incomplete, which cannot fully reflect the ecological health of the river. On the basis of river field investigation, combined with the research of domestic and foreign experts and scholars and my country's actual national conditions, this paper established an index system and method suitable for evaluating the health status of river ecosystems in northern Anhui. A comprehensive, objective and scientific evaluation of rivers aims to provide a basis for scientific management of rivers and even the entire Huaihe River Basin and rational utilization of water resources. The results of river ecosystem health assessments can also provide specific early warning functions for river management to take action to prevent adverse impacts from occurring.

2. Study on Bio-integrity Index of Planktonic Bacteria and Health Evaluation of River Ecosystem

2.1. Biological Integrity Index

Biological stability refers to the relative stability of the composition, diversity and function of biological assemblages in natural habitats, and is the result of the interaction between organisms and the environment [5-6]. As an important method to study the environmental environment of rivers, the Biological Integrity Index (IBI) changes the average value of water environmental quality evaluation through physical and chemical markers, and objectively shows the health of rivers from the perspective of ecosystems. Function and structure Biological stability index is one of the most commonly used and effective evaluation methods for analyzing the causes of river environmental problems, and it is also a method that is currently studied by domestic scholars [7-8].

2.2. General Steps for Ecosystem Health Assessment

(1) Steps for establishing the PSR model evaluation system

The steps for establishing the PSR model evaluation system are as follows: Determine the research field and research scope (division of the research field), evaluate human activities, and determine the pressure caused by human activities [9-10]. According to the characteristics of the study area, analyze the response of the ecosystem to stress (physical, chemical, biological, ecological level and ecosystem function), select appropriate indicators and establish an indicator system, determine the weighted indicators, assign or normalize them. Calculate the overall health index, obtain the health status of the ecosystem in the study area, and analyze the research results [11-12].

(2) P-IBI

The steps of plankton integrity index calculation can be summarized as follows: data collection in the survey area, determination of reference samples and damaged points; index selection; index selection; index assignment and calculation of fish biological integrity index [13-14].

2.3. Principles of Indicator Selection

(1) Scientific and holistic principles

It is necessary to carefully consider the evaluation objects, select the indicators that can reflect the overall health of the river among the many indicators that reflect the ecological status of the river, and fully consider the physical, chemical, biological, social and economic aspects of the river, so as to establish a scientific and complete indicator system [15-16].

(2) The principle of combining qualitative and quantitative

The river ecosystem is complex and changeable, and it is difficult to comprehensively reflect the comprehensive situation of the river only by selecting quantitative indicators. Therefore, it is necessary to combine qualitative and quantitative indicators [17-18].

(3) Hierarchical principle

The hierarchical principle is to stratify multiple indicators that reflect the health of the river, and then refine the indicators on this basis. The hierarchization of indicators can simplify the complex indicator system and reflect the health status of rivers more clearly from multiple perspectives [19].

3. Investigation and Research on Health Assessment of River Ecosystem

3.1. Sample Point Setting and Description

The study site was located in the A River Basin, and sampling was performed every two months from January 2019 to December 2020, for a total of 12 months. A total of 20 sampling points were set in the places where the river A and its tributaries were moderate in size and convenient for the distribution of points.

3.2. Comprehensive Evaluation Method System

Using the biological integrity index to evaluate the quality of biological elements in the bay has obvious advantages, so this paper attempts to introduce the biological integrity index to establish a scientific, reasonable and comprehensive comprehensive evaluation method for the environmental quality of the bay. This method also evaluates from two aspects of water quality and biological factors. The evaluation index system of water quality factors is selected and determined according to the environmental pressure of the bay to be evaluated. The evaluation index system of biological factors is composed of different types of indices. The index system is composed of evaluation factors selected during its establishment. The index system of the comprehensive evaluation method established in this paper is: water quality indexes include physical and chemical indexes. Biological indicators (IBI) include phytoplankton indicators, zooplankton indicators and benthic indicators.

3.3. Data Processing and Analysis

(1) Species density

Density plays a very important role in measuring the rarity of species, the less quantity contained in a unit area, the higher the rarity. For the calculation of planktonic bacteria density (unit: ind./cm2), please refer to the blood count method, the formula is as follows:

$$N_i = \frac{10nV_1V}{V_2S} \tag{1}$$

In the formula: N represents the cell number (ind./cm2) of the i species in the unit; n represents the number of algal cells in a 0.1mL sample (a); V1 represents the volume (mL) for quantitative analysis after precipitation and constant volume; V2 represents the volume (mL) initially used for quantitative analysis; V represents the raw sample volume (mL).

(2) Diversity Index

The diversity index is a comprehensive index reflecting the number or richness of species and the evenness of species. Commonly used diversity indices include Simpson's diversity index, Shannon-Weiner index, hook index, etc. In this paper, the Shannon-Wiener index meter was used to analyze the biodiversity of the community. The Shannon-Wiener index reflects the uncertainty degree of species occurrence, and the larger the value, the higher the uncertainty. Its calculation formula is as follows:

$$H = -\sum_{i=1}^{S} P_i \log_2 P_i \tag{2}$$

In the formula: H represents the Shannon-Wiener index; S represents the number of species; Pi represents the proportion of species i in the community.

4. Analysis and Research on Health Assessment of River Ecosystem

4.1. Establishment of the Indicator System

The water quality indicators that have an impact on the quality of the river mainly include nutrients, transparency and chlorophyll. Other indicators such as heavy metals and petroleum pollution generally meet the national first-class water quality standards. Therefore, dissolved inorganic nitrogen (DIN) is selected in this evaluation method.), phosphate (PO4) and transparency (SD) as the main components of the Jiaozhou Bay water quality index system, as shown in Table 1.

Table 1. River nutrition evaluation criteria

Index	Nutrient rich	Moderate nutrition	Poor nutrition
DIN(mg/L)	0.5	0.4	0.3
PO4-P((mg/L)	0.044	0.04	0.02

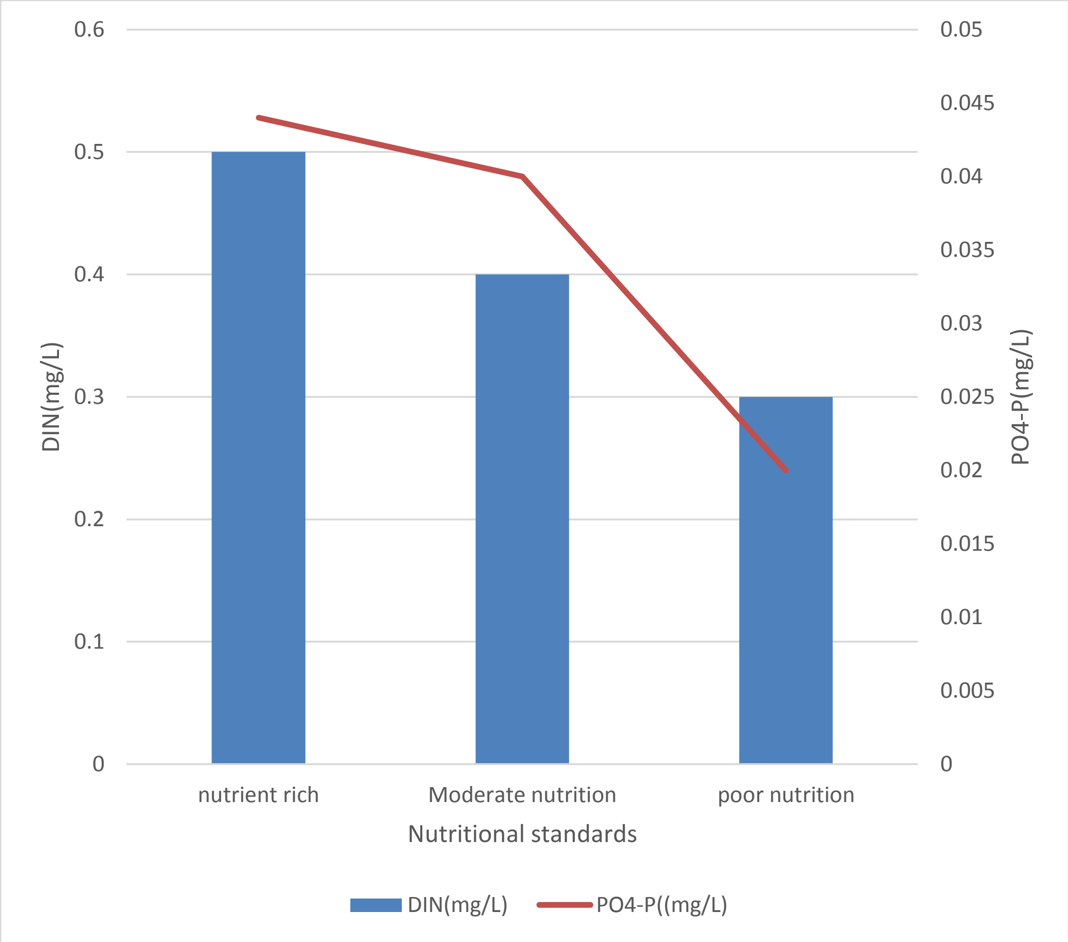

Figure 1. Standard diagram of river nutrition evaluation

As shown in Figure 1, the selection of the evaluation thresholds of DIN and PO4 in the river quality index system is based on the river nutrition evaluation standard. The score was 3 when L-0.3mg/L and 0.3mg/L-0.4mg/L, and 1 when 0.4mg/L or more and 0.1mg/L or less.

4.2. Comparative Analysis of Plankton Integrity Index Evaluation Results

According to the above-established plankton integrity index scoring standard, the score of water area A was calculated, and on this basis, the health of aquatic ecosystems in different periods of water area A was evaluated. The evaluation results of the three-point method, the four-point method and the ratio method are shown in Table 2, respectively.

Table 2. P-IBI value and evaluation results

Time	Rule of thirds	Quartile	Ratio method
1	16	18	20
2	12	22	24
3	20	21	23
4	15	15	25
5	14	19	19

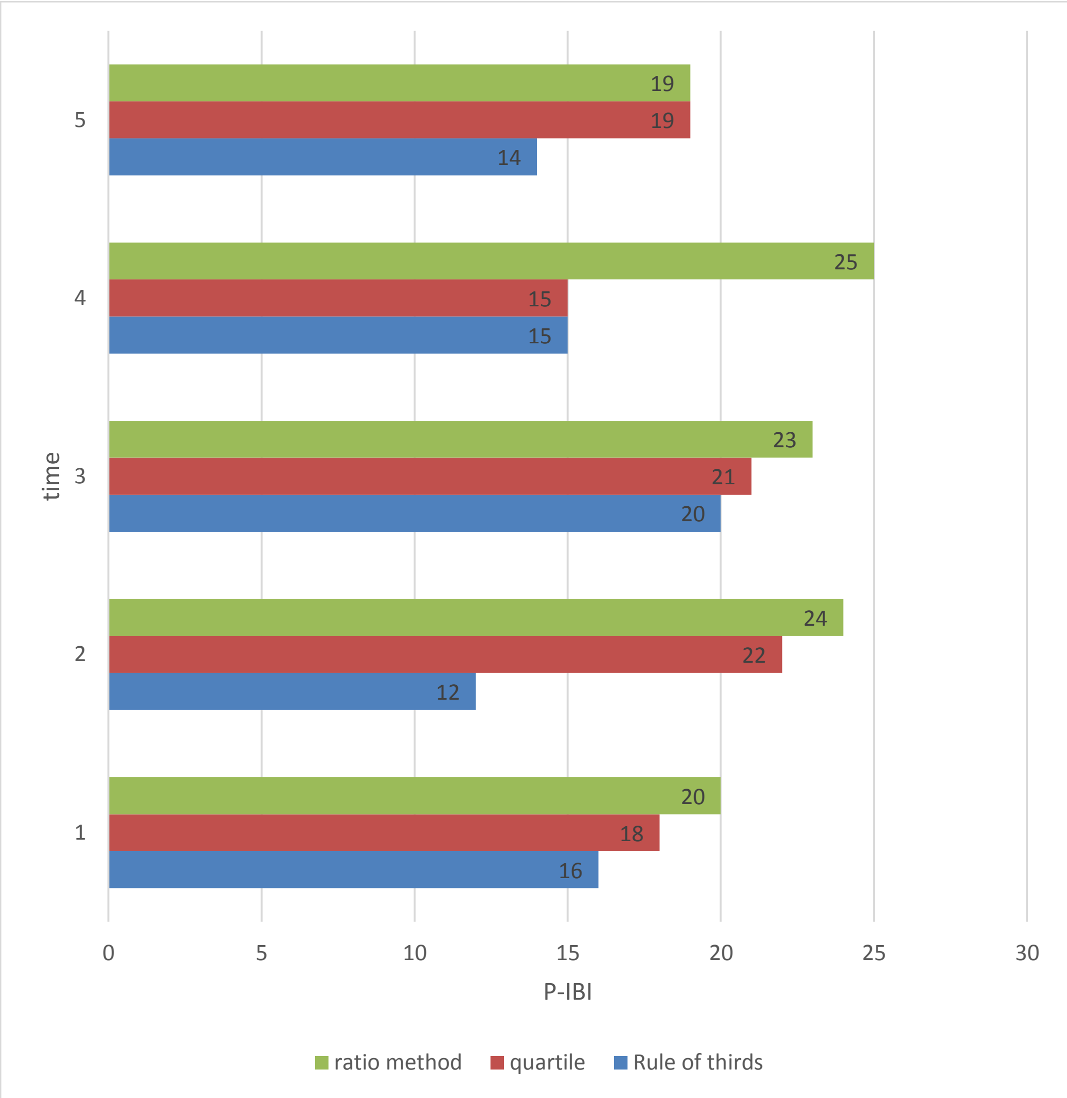

Figure 2. Comparison of P-IBI values and evaluation results

As shown in Figure 2, the Plankton Integrity Index (P-IBI) value of water A calculated by the method of thirds, ratios and quarters was used to evaluate the health of river aquatic ecosystems. Among the 5 monitoring evaluations of the three-point method, healthy is 2 times, sub-healthy is 2 times, and good is 1 time; among the 5 monitoring evaluations of the quartile method, healthy is 3 times, sub-healthy is 1 time, and good is 1 time; Among the 5 monitoring evaluations of the ratio method, 4 times were healthy, 1 time was sub-healthy, and 0 times were good. The evaluation results obtained by the two methods are basically the same. In terms of seasonal changes, the health status in January and November was the worst two months in the anniversary, and the health status was the best in July. The analysis showed that due to the low temperature in winter, it was not suitable for plankton growth, and a large number of plankton died, resulting in poor plankton community structure. Overall health in 2020 is better than in 2019 due to the cumulative effect of pollutants that accumulate over time.

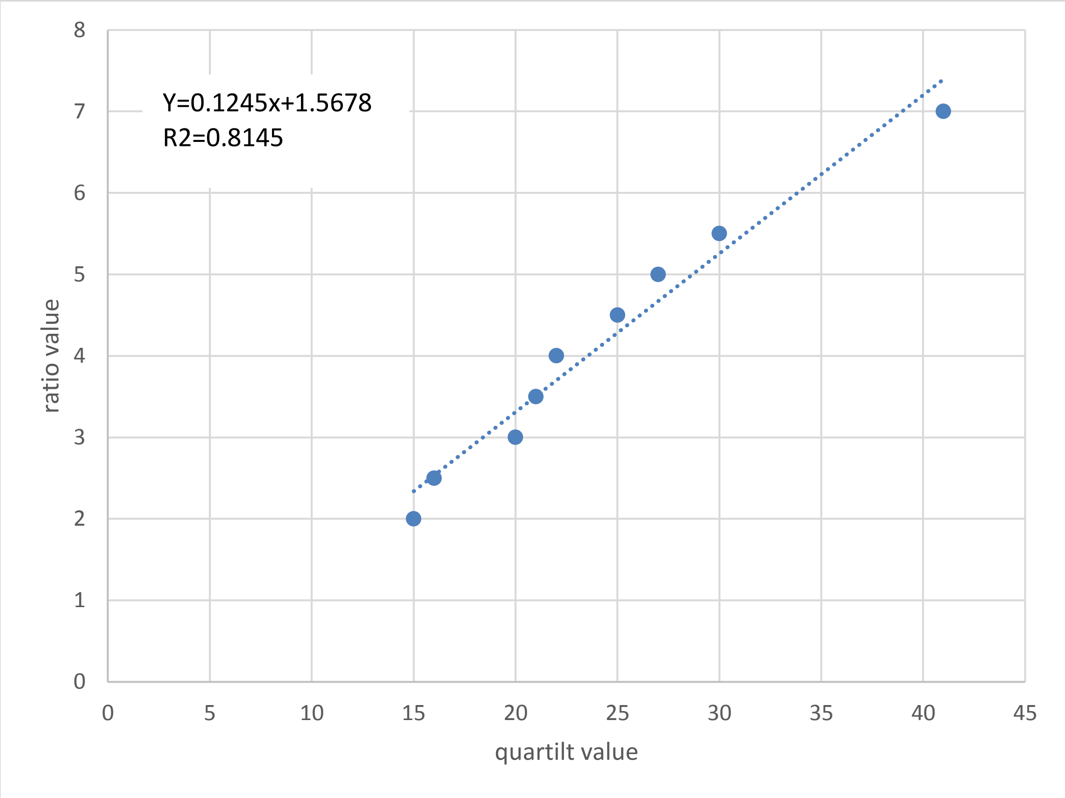

Figure 3. Correlation analysis of P-IBI values calculated by the method of thirds and the ratio method

As shown in Figure 3, the correlation analysis was performed on the P-IBI scores of the waters calculated by the method of thirds, the method of quartiles and the ratio method (Figure 3). The ratio method has a strong correlation with the quartile method, and its evaluation results have a good similarity with the grey relational evaluation results, so the quartile method and the ratio method are both suitable for the evaluation of aquatic ecological health in river waters.

5. Conclusion

This paper studies the health evaluation of river ecosystems based on the bio-integrity index of bacterioplankton. Taking the A river basin as the main research object, the water quality evaluation and biological evaluation of the river ecosystem are carried out respectively, and the river water ecosystem based on the bio-integrity index of bacterioplankton is determined. Health evaluation index system and standard system. Judging from the current water environment in the basin, due to the dual effects of over-utilization of water resources and water pollution, the river water ecosystem is facing problems such as deterioration of water quality, deterioration of habitat conditions, and reduction of water bodies. The measures will affect the overall pollution recovery and treatment process of the Liaohe River Basin, and have a profound impact on the coordinated development of the middle and lower reaches of the Liaohe River and the urban agglomeration in the central Liaoning region, especially the water ecological environment. Therefore, the research on the health status of the water ecosystem in the river basin, and the timely understanding of its health status and the many factors that lead to its decline, will help promote the coordinated development of "socio-economic".

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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