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Fuzzy Comprehensive Evaluation of Qinghe Water Environment Based on Biometric Index of Macrobenthos Community Biological Index

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Abstract: With the rapid improvement of my country's industrialization process, the unreasonable use of water resources, deforestation, vegetation destruction and other phenomena frequently occur, especially the poor public awareness of environmental protection, lack of awareness of the protection of water resources in the Qinghe River, etc. Decline. Studying the Qinghe water environment based on the macrobenthos community biological index can provide a strong scientific basis for the management of the Qinghe water environment. The purpose of this paper is to comprehensively evaluate the water environment of Qinghe River based on the biometric index of macrobenthos community. During the experiment, samples were collected and analyzed for the sample collection method, namely direct hand net sampling in shallow rivers and foot manipulation in deeper water. Using the BI index method, the spatial distribution of macrobenthos species and the fuzzy comprehensive health assessment of the Qinghe water environment were investigated and analyzed.

1. Introduction

Based on the background of global climate change, marine biologists around the world have carried out extensive research on the response of macrobenthos distribution pattern to global climate change. Global warming and sea level rise will significantly affect the distribution pattern of macrobenthos [1]. In addition, because the types and intensity of human activities have different characteristics in different regions and regions, the research on the response of macrobenthos to human activities at the regional scale is also a hot research direction in macrobenthos ecology. Human quantitative research on macrobenthos with the emergence of quantitative sampling tools and the continuous innovation of sampling technology, macrobenthos have gradually transitioned

from the initial single taxonomic research to the research trend of the coordinated improvement of taxonomy and ecology.

In recent decades, the study of macrobenthos has gradually transitioned from the initial study of the distribution characteristics of macrobenthos, the relationship between the distribution of macrobenthos and environmental factors to a more in-depth study.Martin JP investigated soft-bottomed macrobenthos in the intertidal zone to identify animal communities and analyze their relationship to key environmental factors that determine species distribution. Sampling stations were set up on both sides of the discharge point, and four studies in summer, autumn, winter and spring were carried out in the middle and bottom of the area to measure water and sediment variables. To explore possible spatial variation of the area, environmental and biological data were analyzed using univariate and multivariate statistics. Regional composition varies depending on intertidal water levels, sediment characteristics, and distance to sewage treatment sites [2]. According to Losi V, unlike small mollusks, there are few small animal studies related to hard substrates, regardless of their ecological relevance. Since hard-substrate communities are often characterized by species with different lifestyles and strategies than soft-substrate assemblages, information on hard-substrate microfauna is also needed. In this study, sessile macrobenthos and associated microbes were compared at two sites in Portofino (northwestern Mediterranean) at three different depths in subsemi-sedimentary and sedimentary sediments. Animal groups were studied twice. The survey aims to assess the abundance, diversity and composition of small animals and what makes up their assemblage. Furthermore, as microfauna are known to depend on substrate structure, we investigated whether and to what extent microfauna patterns might be related to sessile macrobenthos structure and composition. Macroalgae dominate the sessile macrobenthos, while nematodes and copepods are the main microfauna [3].In the past 100 years, the global climate dominated by human activities has caused great threats to biodiversity, and even caused the disappearance of many sensitive species.

This paper studies the general situation of the Qinghe River and the importance of the water environment of the Qinghe River. The research background and concepts are included in the overview of macrobenthos research, and three major factors, physical factors, chemical factors and biological factors, are analyzed. During the experiment, samples were collected and analyzed for the sample collection method, namely direct hand net sampling in shallow rivers and foot manipulation in deeper water. Using the BI index method, the spatial distribution of macrobenthos species and the fuzzy comprehensive health assessment of the Qinghe water environment were investigated and analyzed.

2. Research on Qinghe Water Environment Based on Biometric Index of Macrobenthos Community

2.1. Overview of Qinghe River

Qinghe River, known as Shaobei River in ancient times, was named Qinghe River in the early Qing Dynasty due to its clear water quality [4]. The Qinghe River Basin is the main stream on the east bank of the Liaohe River system, most of which belong to the low mountain and hilly areas of the Changbai Mountains; it flows through the Qinghe District and Kaiyuan City under the jurisdiction of Tieling. The Qinghe River Basin has a mid-temperate sub-humid monsoon continental climate with sufficient sunshine and four distinct seasons, with rain and heat in the same season. The annual sunshine hours are 2776.6 hours [5]. The average monthly temperature is -17 ℃, the minimum temperature is -41.0 ℃; the average temperature in July is 23.2 ℃, and the maximum

temperature is 35.2 ℃. The average annual precipitation is 741 mm [6].

2.2. The Importance of Water Environment in Qinghe River

Xiaoqing River has various functions, including irrigation, maintenance of ecological environment, flood discharge and so on. Previously, it had good water quality, abundant water, and abundant aquatic life [7]. With the improvement of coastal industries, the Xiaoqing River has received a large amount of industrial waste water and domestic sewage along the way, making its pollution increasingly serious and gradually becoming a river channel for receiving and discharging sewage.

The main problems existing in my country's watersheds are:

First, there is a serious shortage of water resources [8]. The surrounding economy of the Xiaoqing River Basin is improving rapidly, and the level of industry and agriculture has been greatly improved, which has rapidly driven the economic improvement of the Xiaoqing River Basin. At the same time, there are serious problems of water resource waste and water pollution.

Second, the flood control of the basin is threatened [9]. The river channels near the Xiaoqing River Basin are seriously silted, the buildings are aging and degraded, and the dikes are weak.

Third, the water environment is deteriorating day by day [10]. Due to over-improvement, the estuary is silted up; sewage discharge near the river basin aggravates water pollution; soil erosion again reduces arable land, and the improvement of industry, agriculture, and cities worsens the ecological environment of the river basin.

2.3. Overview of Macrobenthos Research

(1) The concept of macrobenthos

Benthos refer to aquatic animal groups that live at the bottom of water bodies for all or most of the life cycle. Benthos are not a taxonomic concept, but belong to the category of ecology [11]. Macrobenthos can be divided into freshwater macrobenthos and seawater macrobenthos according to the different living waters, among which freshwater macrobenthos mainly include linear animals, arthropods, and flat animals. There are many species of macrobenthos with diverse lifestyles. For example, mollusks often attach to stones or aquatic plants, oligochaetes in the phylum Arthropoda inhabit the bottom mud, and triceptera larvae are more likely to build nests[12] .

(2) Research on macrobenthos

The global survey has obtained a large number of benthic specimens, and has recorded in detail the morphological characteristics of benthic animals and the basis for species identification. The species diversity and community structure succession of benthic animals has become a research hotspot, and benthic animals have begun to be used in water environment quality monitoring [13]. Benthos have become key measurement parameters in ecosystem models. The time scale of benthic research is often inter-annual or even decadal, and the spatial scale has also expanded globally. Research involves global changes, especially with global climate variability and human-induced disturbances as the starting point to explore benthic animals. relationship with environmental factors [14].

Compared with foreign countries, the research on benthic animals in my country started relatively late. Chinese scholars have conducted preliminary ecological surveys on benthic animals in some coastal areas [15]. However, limited by the conditions at that time, the research level and sampling method were relatively backward, and the research results were scattered and lacked systematic analysis. With the in-depth study of benthic animals by Chinese scholars, different types

of qualitative and quantitative studies have gradually improved. my country has carried out a systematic survey of benthic animals, and has preliminarily mastered the species composition, resources and distribution of benthic animals in the Yellow Sea, Bohai Sea, Jiaozhou Bay, the Yangtze River Estuary, and the northern waters of China and Vietnam. The research level of benthic animals is improving day by day, and the research focus is not only on the early taxonomy [16]. The research directions of benthic community structure, feeding function, motor function, secondary productivity and other research directions have become the research hotspots of Chinese scholars, and related research also involves data analysis of environmental factors, which makes people have a better understanding of the relationship between benthic animals and the ecological environment. Intuitive understanding.

2.4. Influencing Factors of Macrobenthos

(1) Physical factors

The substrate is the basic condition for the growth and reproduction of benthic animals, and the particle size, stability, heterogeneity and other factors of the substrate have a significant impact on the community structure of benthic animals [17]. It is generally believed that benthic animals are more likely to survive in clay and silt substrates, while sandy and gravel substrates are not suitable for the survival of benthic animals. This is because nutrient-rich organic debris is more likely to be deposited in clays and silts. Water depth can have a direct impact on benthic animals. It is generally believed that the biomass of benthic animals is negatively correlated with water depth. For example, relevant studies have shown that the biomass in the shallow water area of Fuxian Lake in Yunnan is significantly higher than that in the deep water area. This is because as the depth of the water body increases, the dissolved oxygen gradually decreases, the degree of sediment decomposition also increases, and the food quality of benthic animals becomes smaller and smaller, thus limiting the effect on benthic animals. At the same time, different species have different adaptability to different water depths. It is generally believed that chironomids larvae and oligochaetes have stronger adaptability to the deep water environment.

(2) Chemical factors

Temperature is the most common factor affecting benthic animals, and related research has started earlier. It is generally believed that the biomass of benthic animals increases with the increase of temperature within a certain range. Correspondingly, the productivity of benthic animals and the assimilation rate of substances will also increase. The effect of water depth on benthic animals also has the effect of dissolved oxygen [18]. Environmental factors, macro-scale, micro-scale, seasons, and other medium and small scale biological factors, altitude, terrain, climate, land use, physical and chemical factors, aquatic plants, predation, coastal vegetation, human activities, total phosphorus, total nitrogen, ammonia nitrogen, bottom water depth, water temperature, salinity, turbidity, nitrate nitrogen, There is a significant correlation between the conductivity, pH, nutrient transparency, dissolved oxygen permanganate index, and other water nutrient levels and benthic animals. Excessive increase in the content of nutrients such as nitrogen and phosphorus can easily lead to eutrophic blooms in water bodies, thereby disturbing the community structure of benthic animals. In eutrophic water, the dissolved oxygen content decreased, the benthic animals with low pollution tolerance disappeared, and the benthic animals with strong pollution tolerance, such as chironomid larvae and oligochaetes, proliferated and became indicator species.

(3) Biological factors

Aquatic plants are important biological factors affecting benthic animals. They are not only producers of energy and substances, but also play an important role in maintaining the stability of ecosystems. Aquatic plants have the function of absorbing nutrients in water, decomposing organic pollutants in water, regulating and controlling the reproduction of algae, and purifying the living environment of benthic animals. The effects of aquatic plants on different species are not the same. The snails in mollusks prefer to attach to aquatic plants, but the biomass of lamellibranchs is negatively correlated with the distribution of aquatic plants, while most aquatic insects prefer to distribute in waters where aquatic plants are dense.

3. Investigation and Research on Qinghe Water Environment Based on Macrobenthos Community Biological Index

3.1. Sample Collection and Analysis Sample Collection Method

Biological indicators: Macrobenthos use the quantitative box sampling method to quantitatively analyze the benthic animals. First, place a bucket containing a small amount of in-situ water next to the quantitative box, and then use the quantitative box to collect all the sediment into the bucket., The hand net used to prevent benthic animals from drifting away should also be cleaned, and the cleaning water should be poured into the bucket, and the sediment in the bucket should be washed with a 20-mesh sieve. The qualitative analysis of benthic animals by hand net sampling method is as follows:

(1) Hand net sampling directly in shallow rivers

Hold the hand net directly on the river bottom to pick up the bottom and benthic animals, and then rinse the bottom and benthic animals into the bucket. The processing method is the same as that of quantitative samples. The bottom edge of the net mouth is attached to the substrate, and the net mouth faces the direction of the water flow, and all kinds of substrates are washed by hand, so that the benthic animals flow into the net with the water flow, 8 minutes each time. Carefully pour the organisms collected in the net into a bucket containing a small amount of water, add water and stir gently, sieve the sediment with a 20-mesh sample sieve, put it in a plastic bag and take it back to the laboratory as a qualitative sample.

(2) Foot operation in deeper water

It is not suitable for manual operation in deep water, and the feet can be used instead of hands to turn the bottom material so that the organisms flow into the net. The sampling method in still water is the same as that in shallow water. When sampling by hand net, it should be sampled in various habitats as much as possible, and operated by the same person as much as possible to reduce errors. Use a plastic bag as a container, fix with alcohol, and store in a portable refrigerator.

3.2. Sample Analysis Method

Benthos are an important indicator in the biological evaluation of water quality. At present, the BI index method is mainly used to evaluate the aquatic ecological environment at home and abroad. Among them, ni is the number of individuals of the ith taxon, ti is the pollution resistance value of the ith taxon, H is the biological index, and N is the total number of individuals in the sample. In this work, the BI index method was used to analyze and evaluate the monitoring results of benthic animals in Qinghe River. The calculation formula is:

$$BI = \sum_{t=1}^{n} ni \bullet \frac{ti}{N} \quad (1)$$

$$H = \sum_{i=1}^{s} \frac{ni}{N} \log_2 \frac{ni}{N} \quad (2)$$

4. Fuzzy Comprehensive Evaluation of Qinghe Water Environment Based on Macrobenthos Community Biological Index

4.1. Spatial Distribution of Macrobenthic Species

The spatial pattern of the research objects in this paper can be divided into five research areas according to the water environment of the Qinghe River. And there are differences in the number of benthic animal species among different lakes, among which the number of species of Habuta is at most 10, and the number of species of zucchini is at least 3. There are also differences in the proportions of the four types of benthic species in each lake. Among them, aquatic insects are distributed in all lakes. Except for Habtapao, Leymus chinensis and Beiqinpao, the number of aquatic insect species is higher in each lake. All lakes occupy the largest proportion, and the maximum value appears in Erbagubuo and Huoyaohebuo with 7 species. Molluscs were only not distributed in the dental bubble, and the maximum number of species appeared in the Habuta bubble with 7 species. Annelids are distributed in Longhupao, Habuta Pao, Delong Pao, Erbagu Pao, Huo Shao Black Pao and Tiehara Pao, and the maximum number of species appears in Habuta Pao and Delong Pao with 3 species. Crustaceans are only distributed in Habutapao and Amtapo, and both are two species. The spatial distribution of some macrobenthos is shown in Table 1 and Figure 1:

Table 1. Data table of the number of macrobenthic species

Species	Aquatic insect	Mollusca	Annelida	Crustacean
LHP	8.1	7.4	5.4	9.2
HBT	6.3	7.5	4.3	4.2
DLP	7.1	7.3	4.7	6.1
TLH	7.6	6.0	3.1	9.2
YCH	4.3	6.3	3.1	4.2
XHL	6.4	7.2	5.7	6.8
BOP	5.7	6.8	7.1	6.3
ABP	7.1	6.3	9.3	5.9
YMQ	9.3	5.9	8.3	5.8
NSD	8.3	5.8	9.2	6.1

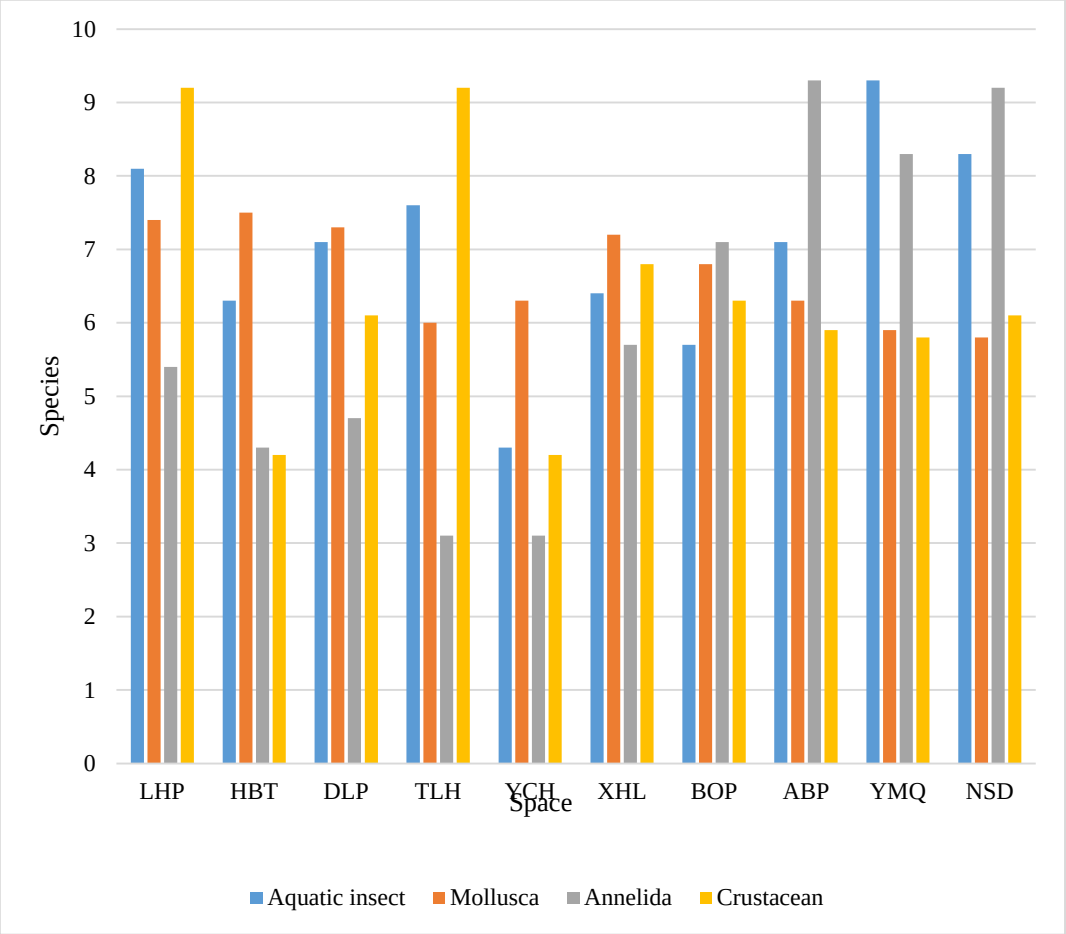

Figure 1. Spatial distribution of the number of macrobenthic species

4.2. Fuzzy Comprehensive Health Assessment of Qinghe Water Environment

With reference to the standard determination method used in the evaluation of water environment quality, a standard system for evaluating the health status of the water ecosystem in the Qinghe River Basin was established. With reference to the set I-V grades, five evaluation grades of healthy, sub-healthy, average, poor, and extremely poor are respectively set. Among them, the water quality standards that meet the second and above grades are set as the healthy grades, and the water quality exceeds the five grades. The standard is set as a very poor grade. The five indicators of the Qinghe water environment monitoring section were re-standardized, and the standardized results are shown in Table 2 and Figure 2:

Table 2. Health evaluation of clear river water environment

Section	DO	COD	BOD	DAA	HQI
1	0.643	0.123	0.012	0.433	0.451
2	0.432	0.241	0.021	0.342	0.592
3	0.564	0.235	0.034	0.186	0.421
4	0.632	0.361	0.012	0.246	0.467

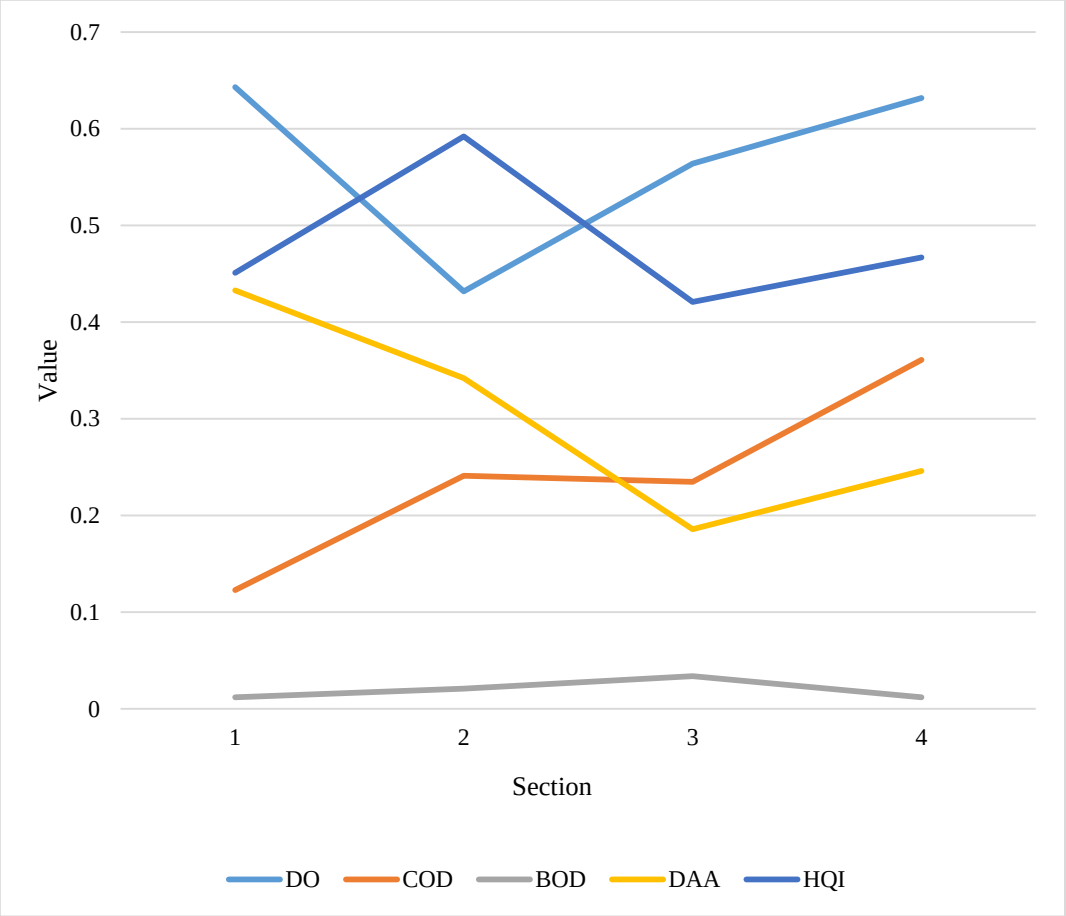

Figure 2. Standardized value of the broken index for each evaluation

According to the interval of the evaluation index, the health level of each section is determined. The evaluation results are shown in Table 3 and Figure 3:

Table 3. Data Table of indicators of each monitoring section

Section	DO	COD	BOD	DAA	HQI
1	0.734	0.232	0.135	0.534	0.513
2	0.689	0.231	0.093	0.216	0.601
3	0.670	0.257	0.212	0.351	0.589
4	0.793	0.312	0.102	0.361	0.591

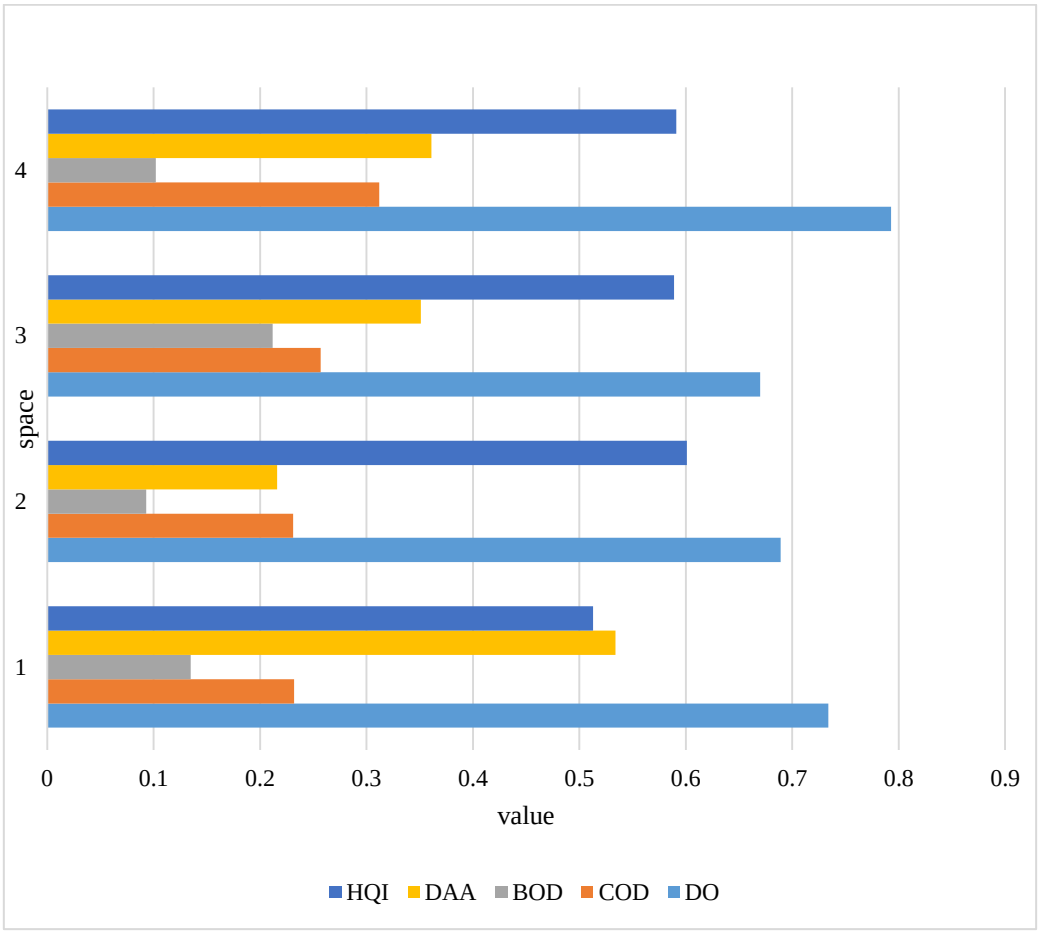

Figure 3. Comparison diagram of the fuzzy comprehensive rating of the water environment

The results of the analysis of biological indicators in the Qinghe River Basin are: the results of the evaluation of benthic animals: the Qinghe River Basin is generally in a clean-moderately polluted state, and the average BI index of benthic animals is 5.2; the BI index is the smallest, which is 4.2, which belongs to clean water; 9.3, it belongs to medium polluted water body. The health evaluation results show that: among the 4 optimized sections, 1 section reaches the "healthy" level, 2 sections reach the "sub-health" level, and 1 section is at the "general" level; there are only 0 sections with evaluation results of "poor".

5. Conclusion

The global ecosystem is also facing threats such as climate warming, sea level rise, abnormal storm surges, etc. These changes mainly caused by human activities have an important impact on the survival, spread and distribution of macrobenthos, such as due to global warming. It will directly cause the sea surface temperature to rise, and the sea level rise will indirectly lead to changes in the physical and chemical properties of intertidal habitats. A key factor in diversity patterns. Under the background of the global scale, due to factors such as rapid population growth and unreasonable economic improvement, the global climate has undergone significant changes, which has had a significant impact on the water environment and macrobenthic biodiversity of the Qinghe River.

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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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