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Advances in research on health assessment methods of aquatic ecosystems

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ABSTRACT
The aquatic ecosystem plays a vital role in the development of human society. It not only provides human beings with basic products for life and production, but also functions to maintain ecosystem structure, ecological processes and regional ecological environment. Assessment of aquatic ecosystem health is the focus and difficulty in the field of aquatic ecology research. It needs to be further developed in research methods and theories. At present, there are two main methods for health assessment of aquatic ecosystems: the index system method and the indicator species method.
Although the index system method is analyzed from the whole ecosystem, this method establishes a large number of indicatorsand needs a lot of information. How to integrate these complex information, and whether the evaluation system can effectively and quantitatively reflect the health status of natural and social attributes of aquatic ecosystems. And whether the comprehensive indicators are reasonable, etc. At present, the problems have not been solved well.The indicator species method is simple and feasible, but it is difficult to reflect the health status of the aquatic ecosystem comprehensively due to the unclear screening criteria for indicator species and their indicative effect on ecosystem health, and without considering the socio-economic and human health factors.
The ecosystem is complex and has a succession process, and there are many uncertainties in the evolution process.The assessment of aquatic ecosystem health also involves factors such as human health, socio-economics and national policies.Therefore, aquatic ecosystem health research still requires a more sophisticated approach to assessing aquatic ecosystem health.

Key words: aquatic ecosystem; ecosystem health; assessment methods; the index system method; the indicator species method

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I. INTRODUCTION

Ecosystem health refers to a systematic diagnosis of the state of ecosystems in the context of ecology in combination with human health[1].Schaeffer et al. first proposed the concept of "Absence of disease" in ecosystem health in 1988 and proposed principles and methods for evaluation[2].Many studies have been carried out on ecosystem health assessment of rivers, lakes, wetlands, forests and cities[3-7], some progress has been made in ecological health assessment indicators.In 1981, Karr et al. pointed out that ecosystem degradation is caused by excessive human interference, and ecosystem health is ecological integrity. Then Index of Biotic Integrity has been widely used in aquaticecosystem health assessment[8].

The aquatic ecosystem plays a vital role in the development of human society. It not only provides human beings with basic products for life and production, but also functions to maintain ecosystem structure, ecological processes and regional ecological environment[9]. The healthy aquatic ecosystem is stable and sustainable, that means it has the ability to maintain its organizational structure, self-regulation, and resilienceto stress over time.The healthier the aquatic ecosystem, the more vigorous it will be, and the greater its ability to recover from disturbances.

At present, there are two main methods for health assessment of aquatic ecosystems: the index system method and the indicator species method[10].The index system methodis that an index system is established based on the characteristics of the aquatic ecosystem and its service functions, and uses mathematical methods to determine its health status. The indicator species method is to monitor the health of aquatic ecosystems by using the diversity and richness of some indicator populations.And in the indicator species method, the biological integrity

index (IBI) is one of the most widely used indicators in health assessment of aquatic ecosystem.

II. THE INDEX SYSTEM METHOD

The index system methodestablishes an index system based on the characteristics of ecosystem and its service functions, and to determine its health status by mathematical method[11].A reasonable index system should reflect not only the overall health levelof water area, but also the changing trend of ecosystem health.

In order to evaluate the ecosystem health of a river basin, the indicators that can characterize the main characteristics of the river basin ecosystem must be selected at the first.The basin ecosystem is a complex ecosystem containing society, economy and nature. The basin natural ecosystem includes terrestrial ecosystem, aquatic-terrestrial ecotone ecosystem and aquatic ecosystem[12].The healthy basin ecosystem is not only ecologically sound, but also economically feasible, capable of providing ecological services that meet natural and human needs.Therefore, the four categories of ecology, physical chemistry, socioeconomic and human health must be taken into account in the evaluation of ecosystem health index system in river basins.

In the basin ecosystem health assessment indicators, most of the indicators can be measured by conventional physical, chemical, biological, field survey and socio-economic survey methods, but some ecological indicators are difficult to measure, such as ecosystem service function, ecosystem stability, integrity, vitality, organizational structure, resilience, coordination among natural ecosystems in river basins. And so on.Schaeffer et al. explored the measurement of ecosystem health for the first time[2], and Rapport et al. developed a measurement formula for the vitality, organization, and resilience of ecosystem health assessment[13].In health assessment, direct measurement, network analysis and model simulation are commonly used index measurement methods[14-16].

The basin ecosystem is a socio-economic-natural complex ecosystem. Each ecosystem in the basin has many components, structures and functions, and each has its own set of independent systems. Therefore, it is necessary to measure the health indicators of each ecosystem in detail[17].

At the same time, the basin ecosystem is dynamic, and the internal conditions change with time. Under the new conditions, the state of sensitive species in the ecosystem also changes accordingly. Moreover, the measurement of some ecosystem health assessment indicators is subjectively different by the evaluator.

Although the index system method is analyzed from the whole ecosystem, this method establishes a large number of indicatorsand needs a lot of information. How to integrate these complex information, and whether the evaluation system can effectively and quantitatively reflect the health status of natural and social attributes of aquatic ecosystems. And whether the comprehensive indicators are reasonable, etc. At present, the problems have not been solved well.

III. THE INDICATOR SPECIES METHOD

Due to the complexity of the ecosystem, it is often necessary to use some indicator taxa to monitor ecosystem health.The richness index or integrity index (such as biological integrity index IBI) of the indicator species method is based on the diversity and richness of the indicator species in the ecosystem.When the ecosystem is subjected to external stress, the structure and function of the ecosystem are affected. The suitable habitats of these indicator species are stressed, and their structural and functional indicators will change significantly.

Therefore, the health of the ecosystem can be expressed by the changes of the structural, function and quantitative indicators these indicator species, and the resilience of the ecosystem can be expressed by the resilience of these indicator species[18].

For example, McCain et al. suggested that silver salmon can be used to indicate the ecosystem health of the Great Lakes region of North America [19].The EPT index evaluation standard used by the New York Environmental Protection Department is that among 100 species of indicator insects, more than 10 species of water are found to be non-polluting, 6-10 species of slight pollution, 2~5 species of moderate pollution, and 0~1 species of serious pollution [20].

The Index of Biotic Integrity (IBI) was first proposed by Karr et al. in 1981[8].According to the concept of “a good aquatic ecological environment, there must be a perfect biological community structure”, several indicators reflecting the species composition, nutritional structure and individual health status of the aquatic ecosystem were selected,and the health degree of the aquatic ecosystem was evaluated by comparing the values of parameters with the standards of the reference system.Biological integrity is the species composition, diversity, and functional structure characteristics of a community in a natural habitat in an area, and the ability of the community to maintain its own balance, maintain its structural integrity, and adapt to environmental changes [21].Initially, IBI was proposed as an evaluation index of water pollution. It not only makes up for the shortcomings of physical and chemical monitoring, but also evaluates the biological integrity of the waters.

Therefore, it has been widely recognized and gradually applied to the research on the structure and function deterioration assessment of bays, estuaries, lakes, wetlands, forests and river basins ecosystems.

Since the introduction of the IBI, its indicator system has developed into many forms.Different researchers choose fish (F-IBI), benthic animals (B-IBI), plankton (P-IBI), or different groups of organisms as objects. According to the characteristics of the study area and aquatic ecosystem, and the availability of data, about 5-10 indicators are selected to evaluate the biological integrity [22,23].

The indicator species method is simple and feasible, but it is difficult to reflect the health status of the aquatic ecosystem comprehensively due to the unclear screening criteria for indicator species and their indicative effect on ecosystem health, and without considering the socio-economic and human health factors.

IV. CONCLUSION

The ecosystem is complex and has a succession process, and there are many uncertainties in the evolution process.The reasons for affecting aquaticecosystem health and the extent to which it affects aquaticecosystem health require further demonstration and summarization.The assessment of aquaticecosystem health also involves factors such as human health, socio-economics and national policies.Therefore, aquaticecosystem health research still requires a more sophisticated approach to assessing aquaticecosystem health.

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