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Index of biological integrity and its research progress in aquatic ecosystem health

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ABSTRACT
In recent years, due to the interference of human activities, the function of aquatic ecosystem has been seriously damaged.In order to manage the health of the ecosystems, the health assessment of aquatic ecosystems has become one of the hot spots in ecological research.At present, there are two main methods for evaluating the health of aquatic ecosystems: indicator system method and indicator species method.In the indicator species method, the index of biological integrity (IBI) is one of the most widely used indicators in aquatic ecosystem health research.This article introduces the concept, principle and construction method of index of biological integrity, and summarizes the application progress of index of biological integrity in aquatic ecological health assessment.
KEY WORDS: aquatic ecosystem, ecosystem health, index of biological integrity (IBI), health assessment

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I. INTRODUCTION

Ecosystem health research is one of the hot spots in ecology. The purpose of studying ecosystem health is to monitor and evaluate ecosystem health, and then to manage ecosystem health and achieve the coordinated development of human and natural ecosystems (Eugene et al., 2004; Griffith et al., 2005). Ecosystem health is composed of ecosystem integrity, system vitality and resilience, of which integrity is the foundation (Wang et al., 2003).At present, there are two main methods for evaluating the health of aquatic ecosystems: indicator system method and indicator species method(Morley et al., 2002; Liao et al., 2013).In the indicator species method, the index of biological integrity (IBI) is one of the most widely used indicators in aquatic ecosystem health research(Butcher et al., 2003; Wang et al., 2016).This article introduces the concept, principle and construction method of index of biological integrity, and summarizes the application progress of index of biological integrity in aquatic ecological health assessment.

II. INDEX OF BIOLOGICAL INTEGRITY

2.1 The concept and principle of IBI

The IBI was first proposed by Karr (1981) and established with fish as the research object.It is composed of multiple biological condition parameters.The health degree of the aquatic ecosystem can be calculated by comparing the parameter value with the reference system standard.The connotation of biological integrity is to support and maintain the stability of species composition, diversity and function of a regional biological assemblage, which is the result of long-term evolution of organisms adapting to the external environment.For any biological community, different biological indicators have different sensitivities to different disturbances and their gradients, such as different strength, different positive and negative, and different sensitive thresholds.Each biological condition parameter in IBI is sensitive to one or more kinds of disturbances.IBI is the quantitative characterization of aquatic ecosystem health status obtained by selecting some biological indicators, considering their sensitivity differences, and reasonably weighting and compounding.Therefore, IBI can quantitatively describe the relationship between human disturbance and biological characteristics, and can more accurately and completely reflect the health status of the ecosystem and the intensity of interference (Karr, 1993, 1995).

When evaluating the health of aquatic ecosystems, according to the characteristics of the biological community structure of the aquatic ecosystem and the availability of data, a certain type of community is selected as the indicator species to construct IBI.According to different biological groups, IBI can be divided into fish-index of biological integrity (F-IBI), benthic-index of biological integrity (B-IBI), plankton-index of biological integrity (P-IBI), alga-index of biological integrity (A-IBI) and aquatic plants-index of biological integrity (AP-IBI) etc.At present,fish-index of biological integrity (F-IBI) (Chun et al., 1996; Pei et al., 2010) and benthic-index of biological integrity (B-IBI) (Kerans et al., 1994; Cao et al., 2010) are the most mature and widely used.

2.2 The construction method of IBI

The construction methods of IBI are becoming more and more rigorous, and the main processes include (Liao et al., 2013; Fore et al., 1996; Kesminas et al., 2000): 1)According to the selected biological groups and their community characteristics in the study area, the candidate biological status parameters were determined in the index database. 2) Reference condition (RC, generally purely natural or near-natural sites) and interference points (sample points that have been subjected to various interferences such as point source and non-point source pollution) are selected. The parameters of candidate indexes were measured or calculated, and the correlation analysis was carried out. Metrics were selected from them according to the principle of mutual independence.3) Determine the index value of each parameter and the calculation method of IBI, and calculate the IBI value of reference point and interference point respectively. 4) The scoring standard of IBI were established. 5) Through the comparison of independent data, the IBI is verified and revised to determine the effectiveness of the IBI method.

Candidate biological condition parameter indicators are very important for the construction of IBI, and different candidate biological condition parameter indicators are selected according to the characteristics of different research areas.The main consideration when selecting candidate biological condition parameter indicators is that the result of the number of species indicator is more than 5, the difference between the sampling points of the percentage indicator is greater than 10%, and the indicator is not 0 for 90% of the sampling points. The indicator should try to cover all indicator types.The basic principle for selecting metrics from candidate indicators is “wide distribution, weak correlation, and good sensitivity (Borja et al., 2008). The division of evaluation standards is the key to the evaluation of IBI, and there is no unified classification standard.Most studies use the 25% quantile of the IBI value distribution of the reference point as the health evaluation standard.If the IBI value of a point is more than 25% quantile value, it means that the interference of the point is very small and it is healthy; for the distribution range of the value of the less than 25% quantile, three equal scores are used to represent three health levels: general, poor and extremely poor (Zhang et al., 2007).

III. THE APPLICATION OF IBI

IBI has been widely used in water ecological science research, resource management, policy and law formulation, etc.At present, the focus of biological assessment of water quality has shifted to assessment of aquatic ecosystem health, and the core of which is IBI assessment.IBI first used fish as indicator organisms to evaluate river health. This method has been recognized by many researchers and applied it to other types of organisms.At present,fish-index of biological integrity (F-IBI) and benthic-index of biological integrity (B-IBI)are the most mature and widely used.F-IBI was first used in streams and rivers in the Midwest of the United States.At present, F-IBI is widely used all over the world.PONT et al. (2006) developed a set of F-IBI aquatic ecological evaluation model for the European continent based on the European Water Framework Directive (EWFD) issued in 2004.The model emphasizes the functional attributes of organisms and weakens the attributes of species, and distinguishes the impact of natural factors and human factors on the environment.Oberdorff and Hughes (1992) used F-IBI to evaluate the impact of human disturbance on stream ecosystems in the Seine River Basin in France.Ganasan and Hughes (1998) used the F-IBI to evaluate the health status of the polluted Khan and Kshipro rivers in India.Zhu et al. (2004) calculated the F-IBI values for four shallow lakes in the middle reaches of the Yangtze River in 1964, 1981, 1993, and 1998.According to the change trend of F-IBI values, it was considered that the water ecological health was declining continuously.The results of F-IBI calculated by Liu et al. (2010) for four lakes from 2003 to 2008 are similar, which proves that the ecosystem service function of the upper reaches of the Yangtze River continues to decline.

The B-IBIwas first proposed by Kerans and Karr (1994) and is the most widely used biological integrity index.Fore et al. (1996) established B-IBI to evaluate the health status of second to fourth grade rivers in southwestern Ohio.Klemm et al. (2003) constructed B-IBI and evaluated the health status of streams in the mid-Atlantic plateau.Silveira et al. (2005) constructed B-IBI and evaluated the health status of rivers in Southeast Brazil. Rossano (1995) used B-IBI to evaluate the health of Osaka stream ecosystem. Wang et al. (2005) established B-IBI to evaluate the health status of streams in Huangshan Mountain, Anhui Province.The results showed that B-IBI was negatively correlated with water conductivity, but positively correlated with habitat index.

IV. CONCLUSIONS

Any changes in the aquatic ecosystem will affect the physiological functions, species richness, population density and community structure of aquatic organisms.Therefore, IBI can not only reveal the health status and structure of aquatic ecosystem, but also reflect the ecosystem function, and evaluate the impact of human activities.Therefore, IBI method is an important means to evaluate the health status of aquatic ecosystem.The construction of IBI is gradually mature on the theoretical basis and technical methods.However, due to the complexity of water ecosystem structure and the richness of functions, there are still some problems in the theory basis and construction method of IBI, which needs further research.

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