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Present Situation and Hotspot of Eco-Hydrological Process Research in China based on Citespace Analysis

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Abstract: In order to fully understand the current hot spots and trends of eco-hydrological research, based on the bibliometrics method and taking 458 relevant literatures from CNKI 2000 to 2021 as the research objects, this paper used the knowledge graph computing tool CiteSpace to carry out visual analysis of the eco-hydrological process in China, and analyzed the research status, hot spots and trends. The results show that: ecohydrological process and ecological restoration are the prefaces of the current ecohydrological research. From 2000 to 2008, the research of ecohydrological field in China is in the rapid development stage, from 2009 to 2015, it enters the stable adjustment stage, and from 2016 to 2021, it accelerates the development stage. The state Key Laboratory of Surface Processes and Resource Economics, State Key Laboratory of Remote Sensing Science, Center for Excellence and Innovation in Tibetan Plateau Earth Sciences, Chinese Academy of Sciences, School of Geographic Sciences, and Cold and Arid Regions Environmental and Engineering Research Institute have close cooperation in eco-hydrology.

Keywords: Knowledge Graph Analysis; Citespace; The Ecological Hydrology; Research Progress and Hotspot.

1. Introduction

Eco-hydrology is an interdisciplinary subject that discusses the influence of hydrological process on the structure and function of ecosystem and the influence of biological process on water cycle elements in changing environment [1]. Although the interdisciplinary research between ecology and hydrology, such as forest hydrology, wetland hydrology and so on, has a long history, the term "ecological hydrology" was not formally put forward at the International Conference on Water and Environment held in Dublin until 1990s [2]. Today, when the country and people attach great importance to ecological environment protection, people gradually realize the importance of harmonious coexistence with nature for sustainable development, and the protection of water resources in ecological environment protection is an indispensable part. The change of regional hydrological process caused by the development and utilization of water resources will inevitably have an impact on the regional ecological environment system. With the implementation of international projects such as the Biosphere Section of Hydrological Cycle (BAHC) and the International Hydrological Plan (UNESCO /IHP2.3 ~2.4) sponsored by UNESCO, the research on eco-hydrological process has been rapidly developed and widely paid attention to, and has become one of the hot spots in hydrology today, and its literature is also increasing [3].

Bibliometric method can objectively and accurately grasp the general situation of research. One of the paradigms of bibliometrics is the scientific knowledge atlas method, which shows the present situation and trend of the research field by visual atlas through early data collection [4]. In scientific research, bibliometrics can effectively determine the research trends in a certain field in a certain stage, provide relevant scientific basis for scientific research projects and topics, ensure research innovation and evaluate academic achievements [3]. CiteSpace is one of the softwares for mapping knowledge map. At present, many scholars have used this software to carry out applied research in the fields of engineering, economy and biology. Therefore, this paper takes ecology as the theme, uses CiteSpace tools and bibliometrics to analyze the development status of domestic eco-hydrological process research field, introduces relevant information of main research forces from the institutional level, and discusses domestic research hotspots and frontier directions in this research field. This is helpful to grasp the latest development trends of eco-hydrology research, provide literature reference for the follow-up development of eco-hydrology, and summarize the characteristics, hot spots and development trends in the past 20 years, so as to provide useful reference for the research and construction of water conservancy scenic spots in the future.

2. Research Methods and Data Sources

2.1. Data Source

In order to ensure the authenticity and accuracy of the data, this paper takes CNKI, which has the largest number of documents and the widest range, as the data source. Advanced retrieval is adopted, with the key words of "Eco-hydrology" and "Eco-hydrological Process", the retrieval time range is from 2000 to 2021, and the data collection time is December 5th, 2021. In order to ensure the quality of qualitative analysis and accurately grasp the development direction of eco-hydrology, papers included in journals were selected as data sources, and articles with low relevance such as newspapers, conferences and reports were excluded, and 458 valid sample documents were obtained, all of which were imported into CiteSpace software in refworks format for analysis.

2.2. Research Methods

CiteSpace software realizes visual analysis by making knowledge maps of key words, research institutions, authors, etc. The node sizes and connections in the knowledge maps reflect the contributions made by related fields and their relationships with each other. Therefore, CiteSpace is used to analyze complex networks with multiple, time-sharing and dynamics, analyze and study the evolution process and

structure system, and then speculate its development trend [5]. In this paper, bibliometrics is used as the research method, and CiteSpace is used to draw the eco-hydrological knowledge map, so as to explore its development trend.

3. Results and Analysis

3.1. Research History

Eco-hydrology was put forward as an independent discipline in Dublin International Conference on Water and Environment in 1992 when the shortage of fresh water resources gradually became a global problem. The ultimate goal of eco-hydrology is to provide a sustainable management paradigm of water resources that is environmentally healthy, economically feasible and socially acceptable on the premise of maintaining biodiversity and ensuring the quantity and quality of water resources [6]. With the improvement of China's comprehensive national strength, the government is paying more and more attention to the ecological water environment, and the investment in scientific research is gradually increasing, which improves the development of ecological hydrology research in China. The number of papers published on CNKI for ecological process research is generally on the rise, which can be divided into three stages: 1) The period of 2000-2008 is a period of rapid development, which has set off the climax of ecological hydrological process research; 2)2009-2015 is a stable development period, and after experiencing rapid development, the research entered an adjustment period 3) After a stable adjustment period, 2016-2021 also ushered in a period of rapid development. The 21st century is called the century of wetland protection and restoration. international geosphere-biosphere program (IGBP), International Hydrological Program (IHP) and China's major scientific research programs (such as the national "973" program, national key R&D program, national scientific and technological support and knowledge innovation project of Chinese Academy of Sciences, etc.) have started a series of major research topics involving wetland hydrology, ecological hydrology and water resources, which provide strong scientific and technological support for wetland protection and restoration. The research of wetland eco-hydrology is guided by the restoration, protection and service of wetland ecosystem, focusing on the process and model of wetland eco-hydrology, ecological water demand, eco-hydrological regulation and water resources management, and the influence of climate change on wetland eco-hydrology, etc. At the same time, we began to pay attention to and attach importance to the study of the synergistic coupling mechanism between wetland eco-hydrological system and socio-economic system. In China, the representative works of systematic research on wetland eco-hydrology include Mechanism, Model and Allocation of Wetland Ecological Water Demand and Wetland Eco-hydrology and Water Resources Management, etc.

3.2. Institutions and Cooperation Networks

458 documents were imported into CiteSpace software, and the contribution map of institutional cooperation was obtained (Figure 1). The State Key Laboratory of Surface Process and Resource Economy, the State Key Laboratory of Remote Sensing Science, the Center for Excellence and Innovation of Earth Science in Qinghai-Tibet Plateau, Chinese Academy of Sciences, the Institute of Geography, and the Institute of Environment and Engineering in Cold and Arid Regions have close cooperation in eco-hydrology.

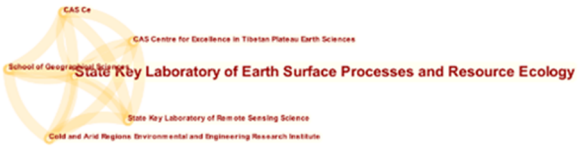

Figure 1. Co-occurrence diagram of major institutional cooperation networks

3.3. Research Hotspot Analysis

Keyword is a high generalization of the research contents, methods and objects of literature. From the distribution of keywords, we can see the research hotspots, innovations and development trends of the corresponding research fields.

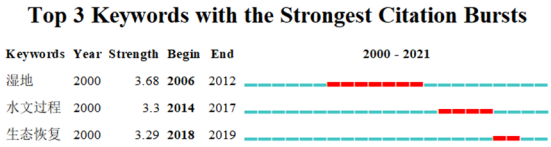

Figure 2. 2000-2021 most cited keyword maps

Potential, keywords can reveal the theme and core ideas of the article. 458 documents were imported into CiteSpace software, and the documents got the three most cited keywords (Figure 3). As can be seen from Figure 2, the keyword with the highest citation number is "wetland", with an intensity of 3.68, which was first cited in 2006, and ended in 2012, and will not be cited after 2012. The second most cited keyword is "hydrological process", with an intensity of 3.3. Its citation started in 2014, and the ending of citation is hot with "hydrological process" in 2017 and 2014-2017. The third key word cited is "ecological restoration" with an intensity of 3.3, which was cited in 2018. It can be seen that "ecological restoration" has been a hot research field in the process of eco-hydrology in recent two or three years. An important research field of eco-hydrology focuses on the relationship between plants and water in terrestrial and aquatic ecosystems. According to the main terrestrial environment or ecosystem types, this problem can be divided into five types of environment or ecosystem types, such as arid areas, wetlands, forests, rivers and lakes [3].

(1) In the past 20 years, ecological water demand (quantity) has occupied an important position in China's ecological hydrology research. In this direction, the quantity of literature is the largest. It can be summarized into several secondary hot spots such as ecological water demand and water demand in the middle and lower reaches of arid inland river basin, ecological water demand for wetland ecosystem maintenance, river water environment water demand and ecological water demand for vegetation ecological maintenance, restoration and reconstruction, etc. Many progress has been made in quantitative evaluation methods, water balance and control measures.

(2) Eco-hydrological process in arid areas. Water is the key ecological factor in arid areas, and the composition and structure of vegetation are closely controlled by water, and at the same time, it gives important feedback to water on various scales. On a large spatial scale, the complexity of the surface in arid areas aggravates the complexity of the relationship between soil, vegetation and atmosphere transmission [8]. At present, the research on climate change patterns and boundary layer dynamics in arid areas is far less than that in grassland

and forest systems [9]. The significance of grasping the feedback between climate and land surface characteristics in arid areas is not only to deeply understand the process involved, but also to understand the actual problems of desertification and land degradation and its climate feedback on regional and global scales.

(3) The relationship between wetland plants and water. Aquatic ecology focuses on the simulation of wetland hydrology and ecological process and the relationship between them, so that the narrow sense of ecological hydrology takes this relationship as its connotation. How the water level of wetland affects the growth and survival of plants, and the influence of wetland hydrological movement process on the structure and spatial pattern of vegetation community are the main research fields of wetland eco-hydrology [10].

(4) Forest hydrological and ecological function and its environmental effects. The research content of forest hydro-ecological function is mainly to understand and understand the relationship between forest vegetation change and water movement, and the associated biogeochemical cycle and energy conversion [11-12] The research of forest hydro-ecological function emphasizes how trees affect surface water transportation and how to affect soil water status through evapotranspiration.

(5) The relationship between plants and water in rivers and lakes. Plants affect the hydraulic characteristics of rivers through the friction of river roughness and river water, and the water flow condition has a profound influence on the survival and growth of plants in rivers. The eco-hydrological process of rivers has long been the core issue of river management and regional ecological and environmental protection. In recent years, the application of theoretical ecology to river management to protect the habitats of biota along rivers, the study of nutrient migration in rivers, flood plains and riparian areas, and the study of the influence of river corridors on regional biological population structure and spatial ecological structure are all very important river eco-hydrological topics [13]

3.4. Analysis of Research Topics

Through the clustering keyword co-occurrence network, draw the high-frequency keyword co-occurrence clustering sequence diagram (Figure 3).

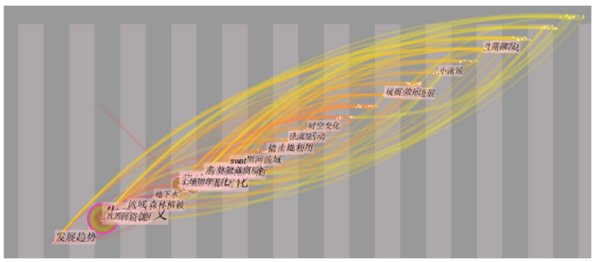

Figure 3. Keywords high frequency co-occurrence clustering timing diagram

The parallel axes in the graph represent different clusters, the node size represents the frequency of keywords, and the location represents the year when keywords first appear. According to the co-occurrence map of keywords in clustering, the study of eco-hydrological process is divided into "eco-hydrology", "small watershed", "ecological restoration" and "forest planting" "Bei" four themes. From the figure, we can see that "ecological water "Wen" has the largest node, which means that "eco-hydrology has the highest frequency.

4. Conclusion and Thinking

Through the visual analysis of the eco-hydrological process in recent 20 years by CiteSpace, the research history, authors and cooperative networks, research hotspots and research trends in this field are clarified, and the following main conclusions are drawn: (1) The eco-hydrological process is in the stage of rapid development in 2000-2008, entering the stage of steady adjustment in 2009-2015, and accelerating development in China from 2016 to 2021. The Chinese Academy of Sciences has initially formed an advantageous force to study eco-hydrological processes, which shows that the Chinese Academy of Sciences is the main research institution in China. In the future research of eco-hydrology, all regions and units should be encouraged to pay more attention to the related research of eco-hydrology. At the same time, the related research structure and the advantages of researchers should be concentrated to form a core research group in the field of eco-hydrology and lead the research development direction in this field [3]. (2) The Chinese Academy of Sciences is the main high-yield institution for the study of eco-hydrological processes in China. The most frequently used keywords in recent twenty years are: wetland, hydrological process and ecological restoration, among which ecological restoration is the hot research direction of ecological hydrological process in recent two or three years. Eco-hydrology, as a decision-making management tool for sustainable development of water resources that is environmentally friendly, economically feasible and socially acceptable, has been studied by ecology. Hydrological experts attach great importance to it and strengthen the basic theoretical research of eco-hydrology, which can fully apply the relatively mature theories of ecology and hydrology. However, the research on the mechanism of eco-hydrology process is still immature and full, and it is in the stage of theoretical exploration. At present, there is no complete and comprehensive theoretical system of eco-hydrology. Hydrological processes in cold regions, such as glaciers, snow cover and frozen soil, cannot be revealed by general hydrological models, or are generalized in most hydrological models. In the future, we should focus on developing distributed hydrological models that can describe hydrological processes of snow and ice and frozen soil in detail [14]. On the study of glacier runoff, the energy balance model based on physical mechanism is difficult to couple with hydrological model at present because of its many input parameters and complicated theoretical structure [15], and the coupling between energy balance model and distributed hydrological model [16] will become the focus of future research. There are still bottlenecks in the modeling of large-scale flow fields larger than 10×104 km2 in terms of process understanding and mathematical expression, scale transformation, coupling mechanism between ecological and hydrological processes [17]. Therefore, in the future, eco-hydrology should strengthen the research on eco-hydrology experiments, large-scale eco-hydrology and restoration eco-hydrology, which is also a research hotspot in the future [3]. (3) In recent years, China's scientific research strength in the field of eco-hydrology has increased, its international status has improved, and the number of scientific research articles has not increased significantly. Therefore, the research on eco-hydrology in China should be strengthened and the

number of papers should be increased. In addition, there is still a certain gap between domestic development and foreign related research, and the quality of the paper needs to be improved. These research results are helpful to grasp the latest development trends of eco-hydrology research and provide necessary support for future scientific research [3].(4) Based on the comprehensive analysis of the development history, research progress and hotspots of international wetland eco-hydrology, the development trend of wetland eco-hydrology in the future mainly focuses on the research of wetland eco-hydrology interaction mechanism based on "multi-factors, multi-processes and multi-scales", the research and development of comprehensive model of wetland hydrology-hydrodynamics-water quality-ecological response, the response mechanism and adaptive regulation of wetland eco-hydrology under changing environment, and the comprehensive management of basin water resources based on wetland ecological water demand and hydrological services.

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