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Progress in the Study of The Carrying Capacity of The Water Environment

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Abstract

At present, the situation of water pollution prevention and control is very serious in China. The total amount control of pollutants in water environment management is the core of the total amount control of administrative target, which is lack of correlation with water quality response.The coupling between pollutant discharge permit allocation and water environment carrying capacity (WECC) is insufficient. The regulation mechanism for allocation of point source discharge permits have not been solved. Therefore, this study takes Changxing County, Huzhou City, Zhejiang Province, a typical plain river network area in East China, as an example. Consider the relevant indicators of WECC (economy and society, pollution load, water resources, water environment, and water ecology), based on the "driving force-pressure-state-responseeconomic benefit (DPSRE)" model and water environmental capacity method, we constructed a collaborative assessment model for the quantity and state of WECC. Through the regulation of WECC and multi-objective optimization, the allocation of point non-point source discharge permits is realized, and we constructed a system of pollutant discharge permit allocation and regulation mechanism based on WECC.

Keywords

Water environment carrying capacity; DPSRE model; Index system.

1. INTRODUCTION

With the advancement of China's industrialization and urbanization and the rapid development of rural planting and farming, a large number of pollutants are generated and discharged into water bodies, making water pollution an increasingly prominent environmental problem that seriously affects China's modernization process [1]. In the face of water shortage, deterioration of water environment quality and water ecological damage to the serious situation, China is increasingly focusing on the management and governance of ecological environment, since the 18th National Congress of the Party, the state will be the construction of ecological civilization into the socialism with Chinese characteristics, "five in one" overall layout. In this context, there is an urgent need to strengthen the constraints and limitations of the top-

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down management system and governance capacity building , and it is a reasonable and effective way to explore the economic development mode under the constraints of the resource and environmental carrying capacity, and the scientific knowledge of the resource carrying capacity has important theoretical value and practical significance for the state to determine the regional strategies and policies, and to develop the development and layout planning .

Water Environmental Carrying Capacity (WECC) is a scientific concept to measure the relationship between human socio-economic activities and water ecosystem, which is an important basis for human to measure sustainable development and management decisions, and provides a good means of quantitative assessment of pollutant licensing emissions. Water body pollution capacity and the state of the water environment has become an important constraint factor for the coordinated development of regional socio-economic and ecological environment, and is also an important factor affecting the carrying capacity of the water environment. There are obvious differences in the carrying capacity of the water environment in different regions, and there is an urgent need to carry out the assessment of the carrying capacity of the water environment in representative regions. The river network area in the eastern plains of China is a strategic location for the coordinated regional development and ecological civilization construction in China, playing a role in promoting the high-quality development of the whole country, and the current quality of the water ecological environment in this area is still unsatisfactory [2-3], and there is an urgent need to carry out a study on the carrying capacity of the water environment.

2. WATER ENVIRONMENT CARRYING CAPACITY STUDY

The carrying capacity of water environment is derived from the concept of water environment capacity and carrying capacity [4], which is a complex system involving natural, socio-economic and other factors, and can be used to measure the degree of coordinated development of regional water environment and human society and economy [5]. At present, there is no unified scientific concept of the carrying capacity of the water environment, which is mainly defined from the perspective of narrow sense and broad sense. The carrying capacity of the water environment in the narrow sense is mainly interpreted by utilizing the water quality or water environment capacity, and the carrying capacity of the water environment in the broad sense refers to the ability of the water environment system to support various social and economic activities of human beings under a certain spatio-temporal state. At the same time, water environmental carrying capacity is a concept that is both different and related to water environmental capacity, water resources carrying capacity and water ecological carrying capacity [6].

2.1. Assessment of the carrying capacity of the water environment

Currently, many methods have been applied to the assessment of the carrying capacity of the water environment, the carrying capacity of the water environment in the narrow sense is mainly estimated using the water environment capacity method, and the assessment methods of the carrying capacity of the water environment in the broad sense can be summarized into two major categories according to the calculation method. The first type of method usually uses the maximum limit of population, GDP or a certain pollutant amount in a certain area to characterize the carrying capacity of the water environment. e.g., Yang et al. evaluated the carrying capacity of the water environment in Tieling City, Northeast China, based on the relationship between pressure-support interaction and the calculation of simulated population and GDP by using a system dynamics model. dou et al..assessed the carrying capacity of the water environment in Tieling City, Northeast China, based on the relationship between water amount, COD and the input-output relationship of the socio-economic system of the provincial area, by using a system dynamics model. system's input-output relationship, and assessed the water resources carrying capacity of Henan Province by simulating regional population and GDP. These studies are in line with the concept of water environment carrying capacity, but the calculation of population and GDP only considered capacity factors, such as water resources or water body pollution holding capacity [7]. The second type of method is the comprehensive indicator system method, which usually establishes an indicator system based on key influencing factors and assigns weights to the indicators to evaluate the water environment carrying capacity. This method is simple and intuitive, and can comprehensively characterize the complex water environment carrying capacity system from multiple levels and dimensions, so most scholars tend to prefer the comprehensive indicator system method for water environment carrying capacity evaluation.

2.2. Methodology for constructing an indicator system for assessing the carrying capacity of the water environment

The construction method system of the indicator system for water environment carrying capacity assessment has not yet been formed. The main construction methods of the indicator system can be summarized into two, one is based on system theory, according to the theory of sustainable development, the system is divided into different levels of sub-systems and indicators, which are both independent and linked to each other, and the other one is based on a fixed framework model to establish the assessment indicator system, such as the pressure-state-response (PSR) model, the PSR model covers the ecological environment, socio-economic The PSR model covers ecological environment, socio-economic and other elements, which is used to characterize the degree of influence of ecological environment by socio-economy, and can reflect the interaction relationship between human activities and ecological environment system more clearly [8], and then scholars put forward more adaptive models on the basis of PSR model, such as the driving force-state-response (DSR) model, the driving force-pressure-state-response (DPSR) model, drive-pressure-state-impact-response (DPSIR) model, drive-pressure-state-impact-response-management (DPSIRM) model, vitality-drive-pressure-state-impact-response-management (VPOSRM) model, and drive-pressure-state-response-Economic Benefit (DPSRE) model. There are many research results on indicator systems, but few studies have integrated the assessment indicator system with regional policy documents from the perspective of management needs [9].

2.3. Weighting methodology

Currently, the calculation methods of indicator weights are mainly divided into three categories: subjective assignment method, objective assignment method and combined assignment method. Subjective assignment method is based on the relevant experience of experts to derive the weight of each indicator, such as hierarchical analysis (AHP), fuzzy comprehensive evaluation method, Delphi method, etc., and the objective assignment method is to assign weights to each indicator through certain mathematical methods, such as entropy weight method, coefficient of variation method [10], etc., and the combination empowerment method is a combination of subjective empowerment method and objective empowerment method. Among them, the subjective assignment method can effectively reflect the actual situation, but is affected by human subjective factors, and the objective assignment method avoids the randomness of the subjective assignment method, but it is easy to ignore the importance of managers to the indicators.

3. STUDY ON THE METHODOLOGY FOR ALLOCATION OF EMISSION PERMITS

Emission permit allocation refers to the ecological environment management department in the premise of meeting the environmental quality requirements and pollution control

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objectives, the use of certain allocation technology methods to control the total amount of division, and after the division of the amount of emission permits allocated to the various sewage units, sewage units in the permit allocation amount to carry out the relevant production and sewage disposal activities of an environmental management method. The key to determine the permitted emissions of pollutants lies in the allocation method [11], by summarizing and comparing the domestic and international allocation methods of sewage permits, the main allocation methods of sewage permits that can be used for practical allocation calculations include the historical data method, the sewage performance method [12], the equiproportionate allocation method, the Gini coefficient method, the weighted composite allocation method of information entropy, and the hierarchy analysis method. analysis method [13] and the equal rights method.

3.1. Emissions Performance Act

The emission performance method is to allocate the permitted pollutant emissions based on the production status and product emission performance values of the emission units. The advantage of this allocation method is that it refers to the current status of emissions, historical emissions, and production technology progress of the discharging unit, as well as operability [14]; the shortcomings are that it does not take into account the variability between different industries and lacks fairness. Li Zeqi et al. combined the entropy-weighted Gini coefficient method and the discharge performance method to construct a model of water pollutant permit emission allocation between administrative units to discharge enterprises, and verified the feasibility of the model. Sun Weimin et al introduced the applicable conditions and advantages and disadvantages of the discharge performance method. Du Huihui et al [15] took Hainan Province as the research object and compared the allocation results of the emission performance method, the economic aggregate method, the regional population method and the comprehensive allocation method, and proved that the comprehensive allocation method was more suitable for Hainan Province.

3.2. Gini coefficient method

The Gini coefficient method is to calculate the Gini coefficient of each indicator to assess whether the formulation of the allocation scheme is reasonable, and if it is not reasonable, the Lorenz curve is used to improve the allocation scheme, which in turn determines the allocation coefficient of the sewage permit. The fairness and scientificity of this allocation method is better, taking into account the differences between sewage units, but the allocation process is complicated, requiring the development of multiple allocation schemes, and cost minimization is not considered. Men Baohui et al carried out the initial allocation of water environment capacity through the equal proportion allocation method, and utilized the Gini coefficient method to evaluate and optimize the allocation scheme. Cheng Yixin et al constructed a single-factor environmental Gini coefficient model and determined the allocation units that led to inequity through the contribution coefficient, and then used the entropy value-environmental Gini coefficient minimization model to formulate an allocation scheme for sewage permits. Guan Xinjian et al [16] constructed an agricultural initial water right allocation model among farmers in the tank area based on the Gini coefficient method based on the agricultural population and irrigated area of the farmers in the tank area, and applied it to Ulanbuhu Irrigation Area.

3.3. Information Entropy Weighted Integrated Allocation Method

The information entropy-weighted comprehensive allocation method refers to determining the weights of each indicator through the entropy weighting method, and then using the indicator data to calculate the comprehensive allocation coefficient to obtain the total amount of permitted allocation for the sewage unit. The advantage of this allocation method is that the

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allocation coefficient is calculated by constructing the indicator system, which can comprehensively reflect the actual situation, and the calculation is simple and operable, and the defect is that the selection of the indicators carries a certain degree of subjectivity. Wu Zhen et al [17] used the information entropy weighted comprehensive allocation method to construct a regional water right initial allocation model and applied it to Yingcheng City in Hubei Province. Song Chunhua et al compared and analyzed the commonly used methods of initial allocation of sewage rights at home and abroad, and concluded that the information entropy weighted comprehensive allocation method can better reflect the differences between sewage units.

4. CONCLUSION

The results of studies on the allocation of sewage permits show that the current allocation methods have their own conditions and limitations. The current method of allocating sewage permits takes into account a single factor, and there are fewer studies that take into account economic and social, industrial planning, pollution control technology and resource efficiency factors in a comprehensive manner. The current sewage permit allocation research objects are mostly fixed sources of pollution, surface sources of sewage permit allocation research has rarely been reported, due to surface pollution of water pollution contribution can not be ignored, there is an urgent need to surface sources into the sewage permit management category. In addition, the current research scale of sewage permit allocation is mostly large-scale watersheds, and there are few studies on the allocation of sewage permits for counties in the river network area in the eastern plains of China.

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REFERENCES

[1] Tang W, Pei Y, Zheng H, et al. Twenty years of China's water pollution control: Experiences and challenges[J]. Chemosphere, 2022, 295: 133875.

[2] Hu GW, Feng HL, Ma YL, et al. Risk assessment and spatial and temporal distribution characteristics of nitrogen and phosphorus pollution in Dongting Lake Basin[J]. Yangtze River Basin Resources and Environment, 2023, 32(1): 162-171.

[3] Pan D, Chen H, Zhang N, et al. Do livestock environmental regulations reduce water pollution in China? Ecological Economics, 2023, 204: 107637.

[4] Xu H, Gao Q, Yuan B. Analysis and identification of pollution sources of comprehensive river water quality: Evidence from two river basins in China[J]. . Ecological Indicators, 2022, 135:108561.

[5] Hao JM, Wang JN, Jiang HQ, et al. Research on national industrial development layout strategy under environmental carrying capacity constraint[J]. China Engineering Science, 2017, 19(4): 20-26.

[6] FAN J, WANG Yafei, TANG Qing, et al. Academic thinking and overall technical process of monitoring and early warning of national resource and environmental carrying capacity (2014 edition)[J]. Geoscience, 2015, 35(1): 1-10.

[7] CUI Dan, LI Rui, CHEN Yan, et al. Evaluation of water environment carrying capacity of watersheds based on structural equations--taking the upstream of Xiaoxia Bridge section in Huangshui Basin as an example[J]. Journal of Environmental Science, 2019, 39(2): 624-632.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202312_9(12).0027

[8] XU Zhiqing, LIU Xueyu, XIAO Shuhu, et al. Study on the evaluation of water environment carrying capacity and obstacle factors in the Pearl River Delta region[J]. Journal of Environmental Engineering Technology, 2019, 9(1): 44-52.

[9] JIA Zimu, CHEN Yan, WANG Huihui, et al. Research on the clustering and zoning method of water environmental carrying capacity of watersheds--taking the upstream of Xiaoxiaqiao section of Huangshui Basin as an example[J]. Journal of Environmental Science, 2017, 37(11): 4383-4390.

[10] Cao Ruoxin, Zhang Kexin, Zeng Weihua, et al. Early warning study of water environment carrying capacity based on BP neural network - A case study of the North Canal[J]. Journal of Environmental Science, 2021, 41(5): 2005-2017.

[11] Li Huan, Huang Xianjin, Jin Yuzhe, et al. Study on the population carrying capacity of water resources in the Yangtze River Economic Zone[J]. Economic Geography, 2017,37(1): 181-186.

[12] Geng Jiao, Wang Yang, Hu Jugang, et al. WQI-based evaluation of river water quality and analysis of spatial and temporal changes in plains river network area[J]. Environmental Engineering, 2022: 1-9.

[13] ZHAI Lina, ZHANG Lei, SUN Zhaohai, et al. Evaluation of ecological safety and analysis of spatial and temporal variability of shallow lakes in the plains river network area: A case study of Baima Lake in Jiangsu Province[J]. Journal of Ecology and Rural Environment, 2021, 37(12): 1559-1567.

[14] Jia Zhuan, Song Guojun, Chen Zhen. Study on the compliance system of fixed-source emission permits[J]. China Environmental Management, 2022, 14(4): 52-60.

[15] WANG Yaqiong, ZHAO Yingcan, SONG Guojun. Research on monitoring and management system of fixed source discharge license[J]. China Environmental Monitoring,2018, 34(3): 8-13.

[16] Zhang Yue, Cai Mulin, Xing Min, et al. Optimization of Total Emission Permit Limits for Control Unit Sources: A Case Study of Yongding River Basin[J]. Journal of Environmental Engineering and Technology, 2023, 13(1): 431-437.

[17] Zhou Jia. Study on the Allocation and Comprehensive Assessment of Permitted Emissions of Air Pollutants [D]. Nanjing: Nanjing University, 2020.

[18] Bai Hui. Research and application of regional pollutant total control method based on water environment carrying capacity [D]. Beijing: China University of Geosciences (Beijing), 2019.

[19] Jokela E J, Dougherty P M, Martin T A. Production dynamics of intensively managed loblolly pine stands in the southern United States: a synthesis of seven long-term experiments[J]. Forest Ecology and Management, 2021, 192(1): 117-130.