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Study on Optimization of Water Pollutant Tax in Inner Mongolia Under the Constraint of Water Environmental Carrying Capacity

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ABSTRACT
It has become a difficult problem for local governments to specify the tax amount of each pollutant involved in environmental protection tax, which lack of support for the theoretical basis and empirical data. This paper takes the Inner Mongolia Autonomous Region as an example, using Time Series Analysis to forecast the regional water environment carrying capacity. It constructs a regional water environment CGE model with water environment carrying capacity as a constraint to evaluate the optimal path of water pollutant tax. The results show that water environmental carrying capacity is the necessary condition for formulating water pollution tax. Besides regions, the types of water pollutants also constraint the taxes. COD pollutants can be taxed according to the current tax amount and the tax of ammonia nitrogen pollutants should be appropriately increased. In addition, the government should also pay attention to the tax effect during legislation.
Keywords: *Water environment carrying capacity, water pollutants; tax optimization, Inner Mongolia, CGE model*

1. INTRODUCTION

The General Provisions of the "Environmental Protection Tax Law of the People's Republic of China", implemented on January 1, 2018, authorizes local governments to determine and adjust water pollutant tax amounts on their own. It stipulates that local governments must consider the local water environment carrying capacity besides the economic development status when formulate tax policy [1]. However, the real problem is the amount of water pollutant tax set in some areas is only a simple shift of sewage charges. Under this taxation model, the effect of tax policies on reducing pollution becomes less obvious. For example, Tang Ming and Ming Hairong[2] found that the current tax amount of water pollutants can only reach 26% of the 10-year average value of the optimal tax amount. The minimum amount of environmental protection tax stipulation is so low that the pollution control cannot be effectively achieved. In this context, this paper focuses on whether the current tax amount of regional water pollutants meets the needs of environmental protection and economic development goals? If not, how should it be optimized?

Water environment carrying capacity is considered to be a scientific criterion for measuring the coordination of water resources environment and economic development[3]. In 2014, the Central Economic Work Report pointed out that the environmental carrying capacity has reached or is close to the upper limit. We must conform to the expectations of the people for a good ecological environment and promote the formation of a new green and low-carbon cycle development method. In order to alleviate the tension between economic development and environmental carrying capacity, it is necessary to combine the problem of optimizing the regional tax amount of water pollutants with the carrying capacity of the water environment. However, the current regional water pollutant tax optimization research is rarely combined with the water environment carrying capacity, and the calculation of the water environment carrying capacity is relatively complicated. Most scholars choose the method of qualitative indicators. For local governments, It is difficult to quantify the specific indicators of water environment carrying capacity. Therefore, it is worthy of further study to quantify the water environment carrying capacity and set it as a constraint to formulate water pollutant taxes [4].

For Inner Mongolia, a resource-based area, the protection of water environment is particularly prominent: on one hand, Inner Mongolia's water resources are unevenly distributed and relatively scarce. And due to the rapid development of high-energy-consuming industries, water resources and environmental problems are intensifying. On the other hand, the current tax amount is far from making up for the cost of environmental governance. It is difficult to achieve the purpose of levying water pollution tax to control pollution, and it cannot solve the problem of water pollution effectively. Therefore, this paper takes Inner Mongolia as an example, decomposes the water environment carrying capacity into two sub-indicators of the maximum supply of water resources and water environment capacity. Through the application of uncertainty mathematical analysis and gray relational analysis to quantitatively predict the dynamic change trend of water environment carrying capacity, and use it as the limiting factor of water environment quality and economic development requirements. This paper builds a regional water environment CGE model with a tax optimization module, and it contains pollution emission coefficients and water consumption conversion adjustment factors. These tax optimization schemes explore when the value of the water pollutant tax, the water pollutant will reach the limit of the regional water environment carrying capacity. It also provides a quantitative tool for the regional governments to formulate pollutant tax amounts, and helps various regions of the country to establish a standard bill for environmental protection.

2. LITERATURE REVIEW

Since January 1, 2018, China levied an environmental protection tax, stipulating that different regions can adjust their water pollutant tax amounts in consideration of their own discharge status. Under this background, a new environmental protection tax is required. Tax rate formulation and optimization are discussed.

Eskeland[5] found in their research that optimizing water pollution tax policies under the constraints of water environment carrying capacity is an effective regulatory and financial means for developing countries. But relevant studies have shown that most local government design taxes have problems that were not connected with environmental carrying capacity. They estimated water pollutant taxes only from the perspective of marginal cost governance with subjective deviations[6-7]. Adnane[3] pointed out that the role of water environment carrying capacity is to balance the supply and demand of water as well as balance water environment and economy. It is a scientific criterion for measuring whether the environment and economic development are coordinated. In order to ease the tension between economic development and environmental carrying capacity, it is necessary to set up reasonable environmental protection tax policies to clear the market space of the ecological environment. Therefore, the research on water environment and related fiscal and taxation policy optimization issues becomes the optimization problem of water pollutant tax amount with water environment carrying capacity as the constraint condition.

The concept widely accepted of water environment carrying capacity is that the water environment capacity or scale can support the socio-economic development under the premise of maintaining a fixed water environment quality goal[8]. However, most scholars have only established a qualitative index system for the calculation of water environment carrying capacity, or only considered a specific river or watershed. They have not conducted a specific quantitative study on the regional water environment carrying capacity[4,9]. Some scholars have tried to quantify the carrying capacity of the water environment, but their research has only established early warning systems without macro economy analysis to optimize the research on water pollution tax[6]. In summary, it is relatively difficult to determine the tax amount directly from the status of pollution discharge and the level of economic development to be scientific and objective. To optimize the tax amount, it is urgent to establish a linkage relationship with the water environment carrying capacity for research.

In summary, the gap of the research is that scholars seldom use a method to organically combine the water environment and economic data in the jurisdiction to simulate the connection between the macroeconomic system and the natural environment. There are three main research methods for optimizing the amount of water pollutants. The first two are the cost estimation method from " Pigouvian tax" and the econometrics method from game theory. They seek to find a balance between the enterprise and the government. Although these two methods are theoretically feasible, it is difficult to achieve the optimal state in practice, and the tax effect after taxation cannot be assessed[10-11]. The third method is the CGE model. This method is one of the most comprehensive methods for considering the economic system. It can not only establish the linkage between natural resources and the economic system, but also can introduce natural systems from different scenarios. On the water environment issue, it makes up for the shortcomings of the partial equilibrium model on the sectors and markets influence analysis in the economy, and the linear programming model cannot introduce the price mechanism into the model[12].

3. CALCULATION OF REGIONAL WATER ENVIRONMENT CARRYING CAPACITY

This paper takes Inner Mongolia, where water resources are scarce, as the research object. Based on the compliance rate of each pollutant, the water pollutant Chemical Oxygen Demand(COD) and the water pollutant Ammonia Nitrogen that are harmful to aquatic organisms are selected as main targets in the study area. By drawing on the related researches of Cui[13] and Xu[14], the paper quantitatively analyzes the water environment carrying capacity from the perspective of the maximum supply of water resources and water environment capacity.

3.1. Calculation of the Maximum Supply of Water Resources

Because surface water resources contain a part of groundwater discharge, and part of the groundwater resources are provided by surface rivers, only deducting the double-calculated water resources in the two is the real total water resources[15]. The maximum supply of water resources refers to all water resources that can be developed and utilized, including developed and undeveloped water resources. The paper ignores factors such as technology and water conservancy projects, and believes that the maximum supply of water resources is the total available water resources. The total amount of water resources in Inner Mongolia has changed significantly. From 2004 to 2012, the supply of water resources showed an upward trend, while from 2012 to 2017, the supply of water resources was down. The region was in a dry season in 2017, and the decreasing trend of water supply is particularly obvious. According to the "Inner Mongolia Water Resources Bulletin" over the years, the average annual water resources in Inner Mongolia is 54.57 billion cubic meters.

There are many factors affecting the maximum supply of water resources, which are constrained by the natural environment such as precipitation and evaporation. Therefore, this section uses the data from 2004 to 2017 as the original data to apply the time series model to predict the future change trend of water resources supply. The prediction results are shown in Table 1.

3.2. Forecast of water environment capacity

The gray system dynamic model cluster method is used to forecast the change trend of water quality concentration, and the complex and variability of the water environment system is fully considered. It is based on the uncertainty theory and uses a one-dimensional static model to measure the water environment capacity. The water environmental capacity of a river is composed of two parts. The first part is the target capacity, which is determined by the difference between the water quality target and the background value, and water flow. The second part is the degradation capacity, which is related to the degradation characteristics of pollutants. The higher the degradation rate, the greater the degradation capacity. Since pollutants are evenly distributed in the river section, the environmental capacity should be independent of the way the river section is divided.

Discretize the time response model to get the gray water concentration analysis model [16] structure:

$$C^{(1)}(T+1)=\left(C^{0}(1)-\mu/a\right)e^{-at}+\mu/a \qquad (1)$$

a,μ: Parameters to be identified; $C^{(1)}(T+1)$: Predicted water quality concentration; $C^{0}(1)$: initial concentration; t:time.

$$W=Q\left(C-C_{0}\right)+KC\frac{L}{\upsilon}Q \qquad (2)$$

W: Water environmental capacity; Q:river flow; C: Maximum allowable concentration of pollutants; C0: Current concentration of water pollutants; K:Pollutant attenuation coefficient; L:River length; v:River flow rate.

As representative water pollutants in Inner Mongolia, COD and ammonia nitrogen are the key factors to study the change trend of water environment capacity. Since the latest input-output table in Inner Mongolia is 2012, the paper uses 2012 as the base year. The data shows that the discharge of water pollutants in 2012 has a large gap compared with 2016. Therefore, we calculate the growth rate according to the data from 2016 to 2017, and reversely introduces the discharge of water pollutants in 2012. The results show that in 2012 COD emissions were approximately 248,800 tons, and ammonia nitrogen emissions were approximately 33,600 tons.

On this basis, the COD and ammonia nitrogen in Inner Mongolia calculated by uncertainty theory in 2012 was 386,700 t/a and 27,600 t/a, respectively. The predicted COD and ammonia nitrogen in the same year is 431,900 t/a and 29,400 t/a, respectively. This result may be due to the large fluctuations in the discharge data from 2012 to 2015 in the Inner Mongolia area, which resulted in a lower predicted value of the average concentration of water pollutants in 2012 and thus a higher water environmental capacity calculation result than the base year.

Table 2 and Table 3 show the forecast water environmental capacity of COD and ammonia nitrogen in Inner Mongolia. It can be seen from the two tables that the water environmental capacity of COD and ammonia nitrogen does not change much. This is because the east-west span of Inner Mongolia is large, the influencing factors are relatively scattered, and the overall change is not large.

Table 1 Forecast results of water resources supply in Inner Mongolia

Years	2018	2019	2020	2021	2022	2023	2024	2025
Maximum water supply (100 million cubic meter)	396.09	425.50	435.52	438.95	440.11	440.51	440.65	440.69

Table 2 Inner Mongolia COD, ammonia nitrogen water environmental capacity forecast value from 2008 to 2016 (million t/a)

Years	2008	2009	2010	2011	2012	2013	2014	2015	2016
COD	0.4203	0.4220	0.4272	0.4293	0.4319	0.4343	0.4364	0.4378	0.4390
Ammonia nitrogen	0.0282	0.0280	0.0286	0.0290	0.0294	0.0296	0.0299	0.0301	0.0303

Table 3 Inner Mongolia COD, ammonia nitrogen water environmental capacity forecast value from from 2017 to 2025 (million t/a)

Years	2017	2018	2019	2020	2021	2022	2023	2024	2025
COD	0.4400	0.4409	0.4416	0.4423	0.4430	0.4433	0.4438	0.4442	0.4445
Ammonia nitrogen	0.0304	0.0305	0.0306	0.0306	0.0300	0.0307	0.0308	0.0308	0.0308

4. MODEL STRUCTURE OF TAX AMOUNT OPTIMIZATION, DATA AND MODEL VALIDATION

4.1. Model Structure of Tax Amount Optimization

In this study, the PEP standard single country static CGE model (PEP-1-1 model) developed by the PEP research network was used to explore the optimization of water pollutant tax in Inner Mongolia, China. The PEP-1-1 model can be widely used in policy analysis of subsidies, taxation, and international trade[17]. The model assumes that it operates in a completely competitive environment, and that the producers and consumers act as the decision-making goals for profit and utility maximization. Since changes in energy policies will have a huge impact on the economy and the environment, it is necessary to consider the activities of multiple sectors in the economy.

In order to optimize the water pollution tax amount, this paper expands on the basis of the PEP-1-1 model and builds a regional water environment CGE model. The model takes into account the behavior of various economic entities such as households, enterprises, and governments, and uses a price mechanism to organically combine supply and demand in the entire link to evaluate economic policy choices. Only the improved part of this paper is introduced below.

According to the existing research, the model construction considers six aspects: First, establish the correlation between the water environment carrying capacity and various economic variables, and use the water environment carrying capacity as the evaluation standard for optimizing the water pollutant tax amount at the regional level. Second, set up adjustment factors to establish the relationship between the model value and the actual data value. Third, decompose the water environment carrying capacity into two variables and consider their constraints on the economy and the environment. Fourth, establish the correlation between the water pollution tax and output through the emission coefficients among the various sectors. Fifth, make all the variables in the model dynamic and observe the dynamic changes in production factors driven by the economic growth in each period will cause changes in the behavior of various economic entities. Sixth, consider various scenarios of water pollutant tax amounts and design optimization schemes. The following are the formulas for the maximum supply of water resources:

$$adjustfactor = QWDAGG / 184.35 \tag{3}$$

$$WS = QWA / adjustfactor \tag{4}$$

$$WS \le \overline{QW_{RE}} \tag{5}$$

adjustfactor: Regulatory factor that converts the amount of value into actual water consumption; QWDAGG: Total water demand in the region; 184.35 cubic meters is the actual water consumption in the base year of the Inner Mongolia Autonomous Region; WS: Actual water supply; QWA: Water output; $\overline{QW_{RE}}$: Water supply capacity restricts actual water supply

The discharge of water pollutants must comply with water quality standards, and the discharge of COD and ammonia nitrogen must be limited by the capacity of the water environment and controlled within the maximum capacity. The following are the formulas of water environmental capacity:

$$TEM_{\text{cod}} \le \overline{W_{\text{cod}}} \tag{6}$$

$$TEM_{\text{an}} \le \overline{W_{\text{an}}} \tag{7}$$

TEM_{cod} :Total emissions of COD pollutants; $\overline{W_{\text{cod}}}$: COD environmental capacity; TEM_{an} : Total emissions of ammonia nitrogen pollutants; $\overline{W_{\text{an}}}$: Ammonia nitrogen environmental capacity.

According to "Water Pollutant Equivalent Value Table", the COD Pollution Equivalent (PE) value of COD is 1, and the ammonia nitrogen PE value is 0.8. The discharge volume is calculated by the discharge coefficient, and the water pollution tax is calculated by using the PE number as the tax base. The equations are as follows:

$$EM_{\text{cod}} = \eta_{cod} \cdot QA_i \tag{8}$$

$$EM_{\text{an}} = \theta_{an} \cdot QA_i \tag{9}$$

$$TEMcod = \sum EM_{cod} \tag{10}$$

$$TEMan = \sum EM_{an} \tag{11}$$

$$EQU_{wp}cod = TEM_{cod} \tag{12}$$

$$EQU_{wp}an = TEM_{an}/0.8 \tag{13}$$

$$WPTAX = twp_{cod} \cdot EQU_{wp^{cod}} + twp_{an} \cdot EQU_{wp^{an}} \quad (14)$$

QA_i: Sector output; η_{cod}: COD emission coefficient; EM_{cod}: Sector COD pollutant emissions； θ_{an}: Ammonia nitrogen emission factor;EM_{an}: Sector ammonia emissions pollutant emissions； $EQU_{wp}cod$: Pollution equivalent number of COD; $EQU_{wp}an$:PE number of ammonia nitrogen ； twp_{cod}:Water pollutant tax of COD; twp_{an}: Water pollutant tax of ammonia nitrogen; $WPTAX$: Water pollution tax.
The twp_{cod}, twp_{an} and $WPTAX$ are the input independent variables we control.

4.2. Data

The CGE model used in this analysis relies on a social accounting matrix (SAM) of Inner Mongolia Autonomous Region, based in the year 2012. The SAM accounts for all income and expenditure transactions of all sectors and institutions in the regional economy, and thus serves as the underlying data framework for the CGE model. In short, the CGE's endogenous parameters come from here.
We choose the latest input-output table, which is from 2012. And the model can be dynamically simulated to 2018 based on the data of the years after the model is built. The basic data comes from the regional statistics of the National Bureau of Statistics: the 2012 input-output table of Inner Mongolia, "Inner Mongolia Statistical Yearbook(2013)", "Inner Mongolia Taxation Yearbook(2013)", " Financial Yearbook of China(2013) ", "2013 Central Government Budget Final Account Revenue and Expenditure Table", "2013 Inner Mongolia General Budget Revenue and Expenditure Final Statement", "2013 Inner Mongolia Environmental Statistics Bulletin" and "Inner Mongolia Water Resources Bulletin". In order to achieve balance of payments, part of the data can be calculated based on the remaining items in the ranks. Based on research needs, the input-output table of 43 sectors is re-divided into production accounts of 10 sectors. The production and supply sectors of water are separated.

4.3. Model Calibration

Because the value of substitution elasticity has a great influence on the simulation results, this paper conducted a sensitivity analysis. The replacement elastic value in the model is increased and decreased proportionally. Change the substitution elasticity between each production factor between -60% and 50%, and observe the range of changes in macroeconomic indicators in this interval. When the elasticity of production substitution is reduced by 60%, the simulation results hardly change, and other indicators are the same. In general, after the sensitivity analysis, it is verified that all the alternative elastic values have high credibility and can be used in the model, and the value of the exogenous parameter has credibility.

4.4 History Fitting

Historical fitting is based on the data of base year to dynamically update the data to the current economic state. The paper set 2012 data as the base year, and updates the model to 2018 according to the actual economic level of Inner Mongolia, so the historical fit interval of the paper is 2012-2018. The paper refers to the Inner Mongolia Statistical Yearbook, adjusts the model according to the actual growth rate, price index changes, etc. to rebuild the model value. As shown in Table 4.

5. SCENARIOS SETTING AND RESULT ANALYSIS

5.1. Scenarios setting

The tax fluctuation scenarios are set up from the following aspects: (1) Take the current tax amount of the region as the base scenario. The impact results obtained by the current policy will be used as the basic reference for other simulation programs; (2) Refer to Chinese scholars [18-19] for the study of the water pollutant tax amount in the western region and take the minimum average value of 3.08 yuan/PE, and increase the tax rate by 0.7 yuan/PE per year based on the current policy; (3) Set the limit factor of water environment carrying capacity in the model and carry out the simulation. It is found that when the tax amount is 3.15 yuan/PE, the ammonia nitrogen emission just reaches the water environment capacity. In addition, the effect of fiscal and taxation policies can generally be seen after 5 years, so the plan 2 takes a 5-year cycle to impact the tax amount; (4) Refer to Chinese scholars' research on the tax amount of water pollutants in the western region and take the maximum average value of 3.95 yuan/PE, and set the plan based on the maximum tax amount prescribed by the tax law. The parameters reflected in the model as twp_{cod}, twp_{an} and $WPTAX$. As shown in Table 5.

5.2. Results analysis

5.2.1. Impacts on the macro economy

The increase in water pollutant tax will have a negative impact on real GDP and other indicators, as shown in Table 6. As the increase in taxation has a more pronounced negative effect on the economy, the economic downturn is also more pronounced. However, the macroeconomic losses caused by it are controlled within 1%, so these water pollutant tax optimization schemes cause economic losses to be within the acceptable range. Therefore, any one of the optimization schemes cannot be excluded from the decline in sector output and macroeconomic losses.

Table 4 Inner Mongolia's macroeconomic growth rate

	Real growth rate in 2013（%）	Real growth rate in 2014（%）	Real growth rate in 2015（%）	Real growth rate in 2016（%）	Real growth rate in 2017（%）
GDP	5.99	5.57	0.35	1.66	-11.21
Resident consumption	13.34	15.84	5.36	7.33	7.63
Government spending	5.73	-15.69	1.30	8.77	0.20
Fixed capital formation	18.01	-11.99	2.90	-9.79	-16.79
Net exports	52.02	-45.66	16.34	-31.09	5.75
GDP deflator	2.81	8.53	8.91	10.72	-1.69

Table 5 Simulation scenarios setting of water pollution policies

scenarios	Scenario hypothesis
Benchmark scenario	$WPTAX$: 2018: 1.4 yuan/PE; 2019: 2.1 yuan/PE; 2020: 2.8 yuan/PE;
scenario 1	$WPTAX$ 2018: 3.08 yuan/PE; 2019: 3.78 yuan/PE; 2020: 4.48 yuan/PE.
scenario 2	twp_{an}: 2018-2022: 3.15 yuan/PE;2023-2025:7.3 yuan/PE. twp_{cod}: 2018-2022: 2.1 yuan/PE; 2023-2025: 4.2 yuan/PE.
scenario 3	twp_{an}: 2018-2022: 3.91 yuan/PE; 2023-2025: 7.82 yuan/PE. twp_{cod} 2018-2022: 2.8 yuan/PE; 2023-2025: 5.6 yuan/PE.

Table 6 Changes in macroeconomic indicators compared to the baseline scenario

Indicators (%)	scenario 1	scenario 2	scenario 3
GDP	-0.0637	-0.0826	-0.0827
Export to other countries	-0.1044	-0.1350	-0.1387
Resident consumption	-0.0443	-0.0576	-0.0619
Import to other countries	0.6234	0.8057	0.8910
Export to other provinces	-0.5344	-0.6909	-0.7296
Imports from other provinces	0.3251	0.4193	0.4300

5.2.2. Impacts on the environment

By comparing the COD emissions and COD environmental capacity in different scenarios, Figure 1 shows that the COD emissions reduce with the up of the water pollutant tax, and COD emissions were much lower than their water environmental capacity under current policies and three schemes. This shows that the COD emissions meet the requirements of environmental goals. Compared with the baseline scenario, it is found that the reduction in COD emissions under the tax optimization scheme is more obvious. It can be seen from Figure 1 that the future increase in COD emissions is faster than the increase in COD water environmental capacity, so it is necessary for economic development to increase water pollutant taxes in the future.

It is found that the ammonia emissions in the current scenario have far exceeded its water environment capacity in Figure 2. Before 2025, the ammonia nitrogen emissions of scenario 1 have always exceeded its water environment capacity, so the design of the ammonia nitrogen tax for scenario 1 does not meet the environmental requirements. The design of scenario 2 and scenario 3 is divided into three stages, with the first stage from 2018-2022, and the second stage from 2023-2025. The ammonia nitrogen emission of scenario 2 in the first stage exceeds the water environmental capacity slightly, and the ammonia nitrogen emission in the second stage is almost equal to its water environmental capacity. The ammonia nitrogen emission under scenario 3 is lower than its water environment capacity at each stage. If only the environmental benefits are considered, the emission in the case of scenario 3 is the lowest, but the higher water pollutant tax will result in less output of the sectors. To balance both economy and environment, we must follow the principle of tax amount optimization and choose the minimum tax amount that just meets the environmental requirements as the optimized tax amount. Considering factors such as water environment capacity error, scenario 2 is better.

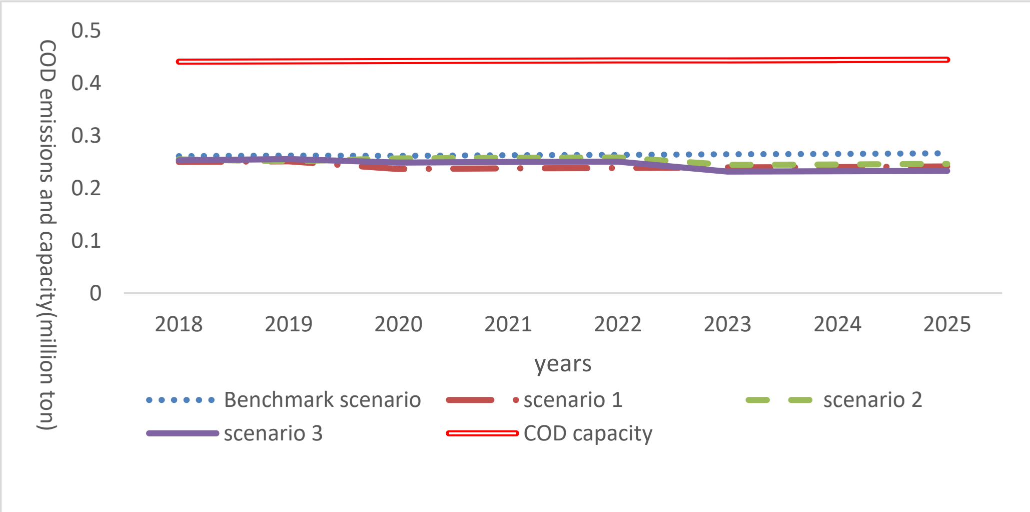

Figure 1 Comparison of COD emissions and their capacity

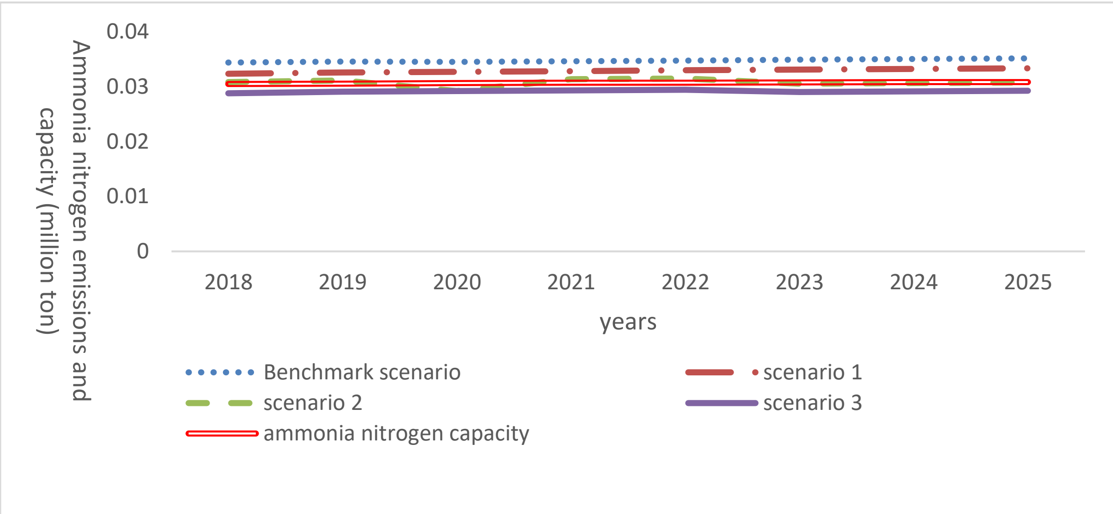

Figure 2 Comparison of ammonia nitrogen emissions and their capacity

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

Comprehensively considering various factors such as macroeconomics and environment, the study found that: First, the increase in the tax amount of water pollutants will lead to a decline in macroeconomics, but the decline is acceptable within a reasonable range. The three scenarios keep the output of the decline of the macro economy within a reasonable range, so the three scenarios are feasible under this consideration. Second, For the environment, it was found that the COD emissions did not exceed its water environment carrying capacity under the baseline scenario and the three scenarios, while the ammonia nitrogen emissions all exceeded on the same scenarios. Therefore, the water pollution tax should be set separately according to the type of pollutants. After considering three scenarios, COD pollutants can continue to be taxed according to the current tax amount. For ammonia nitrogen, the ammonia emissions of scenario 1 before 2025 all exceed its water environmental capacity, so the design of the ammonia nitrogen tax for scenario 1 does not meet the environmental requirements. If only the environmental benefits are considered, the ammonia nitrogen emission under scenario 3 is the lowest. If the purpose is to take into account both the economy and the environment, the principle of tax amount optimization should be followed to select the minimum tax amount that just meets the environmental requirements as the optimized tax amount. In summary, considering the factors such as water environmental capacity error, scenario 2 is better.

COD pollutants can continue to be taxed according to the current tax amount, that is, the tax amount in 2018 is 1.4 yuan/PE, the tax amount in 2019 is 2.1 yuan/PE, and the tax amount from 2020 to 2025 is 2.8 yuan/PE. Ammonia nitrogen pollutants should be appropriately increased based on the current policy of 1.4 yuan/PE. After quantitative analysis, it is concluded that the theoretical optimization of the ammonia nitrogen tax is 3.15 yuan/PE in 2018-2022, the ammonia nitrogen tax is 7.3 yuan/PE in 2023-2025.

6.2. Recommendations

6.2.1. The design of water pollutant tax amount should be connected with the water environment carrying capacity

A water pollution tax that does not consider environmental and economic constraints cannot effectively solve the problem of water environment pollution. As a policy to balance the relationship between the environment and the economy, the water pollution tax can amend the previously agreed view that the water pollution tax is set for pollution control and has nothing to do with the economy. In fact, the water pollution tax only considers the balance between environment and economy, and does not consider the constraints of environment and economy. In this way, when the discharge exceeds the environmental target requirements, the water environment will still deteriorate. If the treatment of water pollutants in the region is not adjusted by the carrying capacity of the water environment, the contradiction between environment and economy will become increasingly prominent. Therefore, it is recommended that the local government design the water pollutant tax amount to be connected with the water environment carrying capacity to ensure the scientific rigor of the design method.

6.2.2 The water environmental carrying capacity of various types of water pollutants is different, and the tax amount should be optimized according to the type of water pollutants

The study found that different water pollutants have different degrees of damage to the environment, even under the same environmental quality requirements, the maximum discharge of various water pollutants that the water body bears is also different. The unified tax amount may cause the tax amount of each water pollutant to be too high or low, which may not achieve the goal of protecting the environment. For this reason, in addition to adopting the differential tax in each region, the water pollutant tax amount should also be applied to each type of water pollutant. The central government gives local governments the right to determine the water pollutant tax amount that is suitable for their own development. The local government should actively quantitatively analyze the current status of the discharge of various water pollutants in the region and truly adapt to local conditions.

6.2.3. Appropriately raise the ammonia nitrogen tax rate

By comparison with the water environment carrying capacity and model results, the ammonia nitrogen emissions under the current policy have exceeded its water environment capacity, which means that the current tax policy does not protect the environment. In order to protect the water environment, the amount of ammonia nitrogen tax should be appropriately increased to reduce its emissions below the water environment capacity, so that the water pollution tax policy can really play a role in environmental management.

6.2.4. The key to optimizing the tax amount is to analyze the tax amount effect

Through research, we can see that the increase of pollutant tax will have a negative impact on the economy, but the overall impact is not large. For the environment, the increase in the tax amount of pollutants has a significant effect on the reduction of chemical oxygen demand and ammonia nitrogen emissions, and the amount of emissions will decrease marginally as the tax amount increases. While paying attention to environmental benefits, the government should also pay attention to the tax effect. The optimization plan is determined by the effect, the government's optimization process is reduced, and the coordinated development of the water environment and the economy is achieved.

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