Environmental impact assessment of dynamic simulation of water saving and emission reduction in Hebei Province

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Abstract:
In recent years, the shortage of water resources and water pollutant emission in Hebei province have been accelerated with the process of urbanization[1]. In order to solve the problems, this paper constructs a comprehensive dynamic simulation model of socio-economic, water pollutant discharge and water resources cycle based on material, water resources, value balance and input-output table. The study shows that under the best scenario (the introduction of new irrigation technology and new sewage treatment technology and new domestic faucet policy), In order to reach the 13th Five-Year Plan of water pollutant removal rate and water-saving targets, Hebei province needs to subsidize for new sewage treatment plant 8.7 billion RMB, build 47 new sewage treatment plants and subsidize for household faucets 1.01 billion RMB ,besides, Hebei Province needs to subsidize for new irrigation technology 11.03 billion RMB .

Key words: *dynamic simulation; water pollutant discharge; water saving; environmental economy;environmental policy*

1 Introduction

In recent years, the process of urbanization and the economic development of Hebei have been accelerated, the contradiction between water supply and demand have been deepened. From 2005 to 2012, Hebei province's economic growth rate remained at around 10%. And the resident population in 2015 was 74.25 million, the use of water resources is greater than 25 billion cubic meters, the total discharge of water pollutants is greater than 200 million tons. In order to improve the environmental conditions, the "13th Five-Year Plan of water environment" clearly pointed out that Hebei province should control the total water consumption within 22 billion cubic meters in 2015-2020, and reduce water pollutant emission rate by 19%. At present, Hebei province’s water-saving technology and sewage treatment technology is not yet perfect, the introduction of new and efficient sewage treatment technology and new water-saving design can effectively increase the supply of recycled water.

Many scholars have done research on water abatement in Hebei province, but the analysis on emission reduction targets in Hebei is not exhaustive. In this paper, a dynamic optimization evaluation model of the effect of using the new sewage treatment technology and water saving design of the environmental economy of Hebei province is established

2 Dynamic optimization model of environmental economic impact on water saving design of sewage treatment in Hebei province

2.1 Model framework

The dynamic optimization evaluation model of this paper includes one objective function and three sub models, socioeconomic model, water pollutant emission model and water cycle model. The socio-economic model describes the relationship between capital input and output. The water pollutant emission model describes the relationship between socioeconomic activities and water pollutant emissions. The water cycle model describes the relationship between water supply and demand.

2.2 Objective function

The main purpose of this paper is to achieve maximum economic growth under the requirements of the water environment. Therefore, the objective function of this paper is set as the maximum GRP of HebeiProvince.

$$GRP(\mathrm{t}) = \sum_{\mathrm{m}} \beta^{\mathrm{m}} \cdot X^{\mathrm{m}}(\mathrm{t}) \tag{1}$$

2.3 Water pollutant discharge model

This paper mainly studies three kinds of water pollutants: COD[2], T-P, T-N. The total amount of water pollutants in Hebeiprovince is mainly determined by industrial emissions and residents emissions. Sewage treatment[3-7] plants also handle a certain amount of water pollutants each year. The water pollutant load also can be reduced by the river.

$$TO_i^p(t) = (1-\mathrm{s}) \cdot HO_{\mathrm{i}}^{\mathrm{p}}(\mathrm{t}) + UIO_{\mathrm{i}}^{\mathrm{p}}(\mathrm{t}) - SEO_{\mathrm{i}}^{p}(t) \tag{2}$$

2.4 Water cycle model

VW The total water supply UST in HebeiProvince is composed of groundwater FW, surface water NW, reclaimed water VW[8] and foreign water YW. besides, the total demand for water resources UDT[9-10] is made up of residential water use VWD and urban landscape water use GWD, In addition, the introduction of new irrigation techniques[11-12] and new domestic faucets can save water.

$$UST_{\mathrm{i}}(t) = FW_{\mathrm{i}}(t) + NW_{\mathrm{i}}(t) + VW_{\mathrm{i}}(t) + YW_{\mathrm{i}}(\mathrm{t}) \tag{3}$$

$$UDT_i(\mathrm{t}) = NWD_i(\mathrm{t}) + VWD_i(\mathrm{t}) + GWD_i(\mathrm{t}) - GH_i(t) - WE_i(t) \tag{4}$$

2.5 Socioeconomic model

According to the market balance requirements, the total output of each industry X^m is greater than or equal to the sum of the final demand and the intermediate input, D^m represents the input and output coefficient of the respective industry, W on behalf of the total consumption, I^m on behalf of the m-m industry's total investment, θ^m on behalf of Sewage treatment and water-saving design impact on the development of various industries, O on behalf of the total net exports.

$$X^m(t) \geq W(t) + A^m(t) + O^m(t) + \theta_m^b \cdot I_i^b(t) + \theta_m^c \cdot I_i^c(t) + \theta_m^e \cdot I_i^e(t) + D^m \cdot X^m(t) \quad (5)$$

3 Scenarios

Table.1 is the scenario settings table. Scenario 1 is a scenario that does not introduce any water pollution control and water saving design scenario. Scenario 2 introduces new sewage treatment technology and new domestic faucet.Scenario 3 introduces new sewage treatment technology and new domestic faucet and new irrigation technology.

Table .1- scenario settings table

Scenario	water pollution control target Water pollution reduction of 30%	economic growth target GRP growth rate remained at 7%	water use target water use control in 20 billion cubic meters
Scenario 1	Unimplemented	implementation	Unimplemented
Scenario 2	Unimplemented	Unimplemented	implementation
Scenario 3	implementation	implementation	implementation

4 Analysis of the best scenario

4.1 Optimal scenario selection

We select three indicators from three models, and according to these indicators,we select the optimal scenario. The specific contents of the indicators are shown in *Table.2.*

Table.2- Scenario setting

	water pollution	subsidy new irrigation	subsidy new home faucet	subsidy introduction new sewage
Scenario 1	10.8%	No	No	No
Scenario 2	19%	No	Yes	Yes
Scenario 3	42%	Yes	Yes	Yes

4.2 Change of GDP in the optimal situation

Fig.1 shows the change of GDP in Hebei province from 2012 to 2030. From the figure, the GDP of Hebei province has a slow growth rate in the prime, then go down.This may be due to the fact that the model has imposed more stringent restrirowth ctions on water consumption and water pollutant emissions in 2030,so the pace of economic growth is much slower.

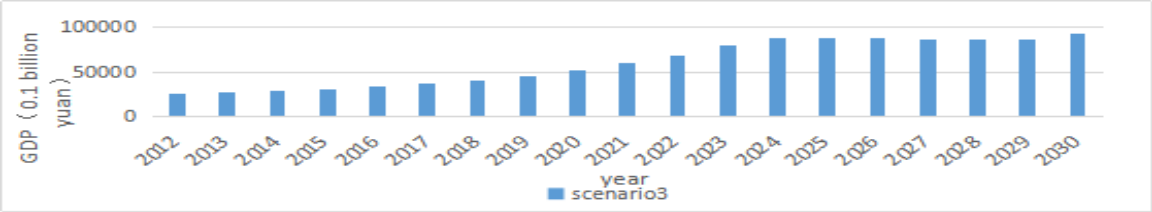

Fig.1- Variation of GDP in Hebei province from 2012 to 2030

4.3 Analysis on the impact of water environment on optimal environmen

Fig.2 shows the change of total water pollutant load in Hebei province from 2012 to 2030. In the optimal scenario, the COD load in HebeiProvince decreased by 59% in 2012, 78% in total phosphorus and 83% in total nitrogen.

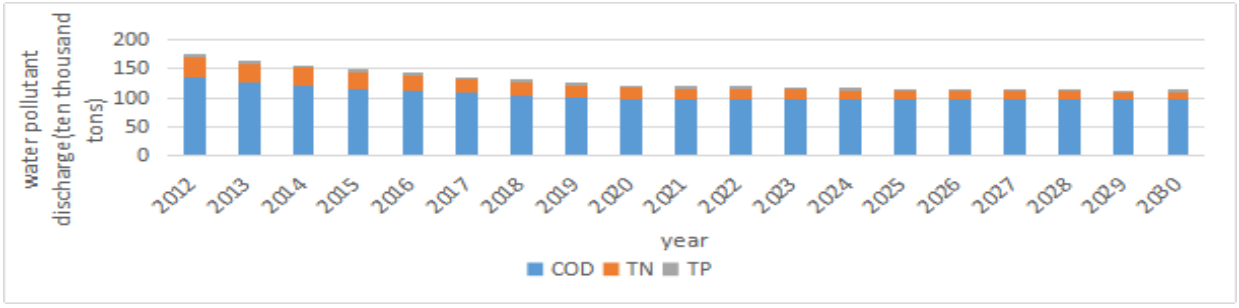

Fig.2-the change of total water pollutant load

4.4 Analysis of water resources supply and demand in optimal scenario

From the use of water resources (*Fig.3*), the consumption of industry water is decreased year by year, while the consumption of urban water and landscape water merely change a little.

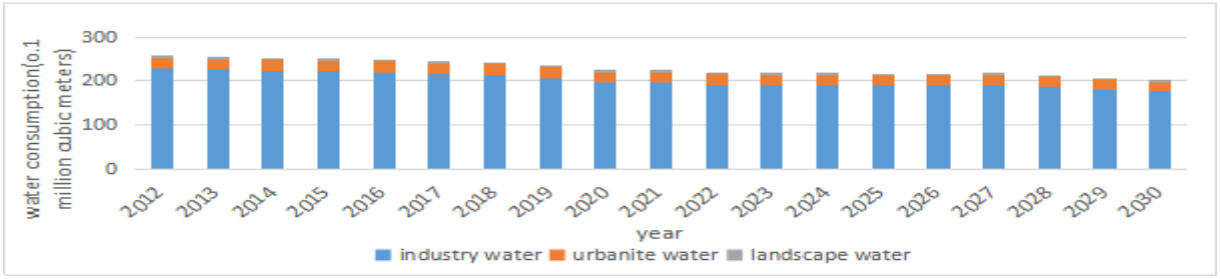

Fig.3-the use of water

4.5 Analysis of comprehensive strength of cities in the best situation

Fig.4 is the average GDP growth rate of city in 2012 to 2030, we can see that Tangshan, Handan, CANGZHOU have a rapid economic growth rate, while XINGTAI, CHENGDE have a slow growth rate.

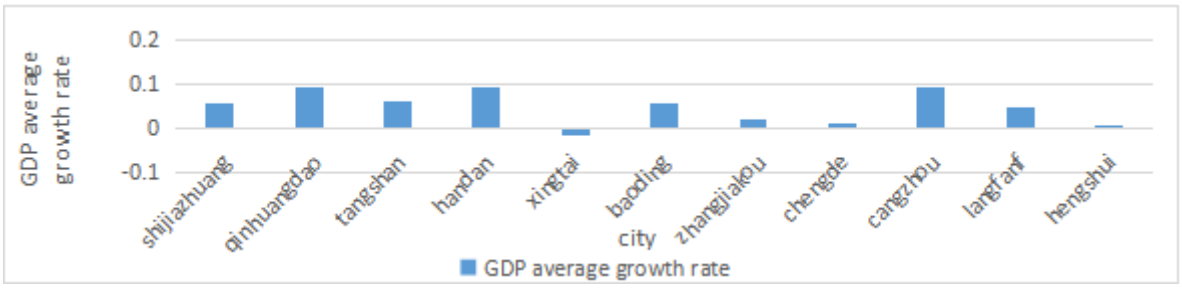

Fig.4-the average GDP growth rate of city

5 Conclusions and suggestions

Through the simulation results(*Table .3)*, we made the following recommendations:There are several cities need to build new sewage treatment plants, the specific number of the treatment plants are shown in following table,particuliarly, XINGTAI in 2018, 2019, respectively, needs to build 5 and 11 sewage treatment plants by using new MBR sewage treatment technology.CHENGDE needs to build 7 sewage treatment plants by using new MBR sewage treatment technology in 2018.(1-11 on behalf of Shijiazhuang, Tangshan, Qinhuangdao, Handan, XINGTAI, Baoding, Zhangjiakou, CHENGDE, CANGZHOU, LANGFANG, HENGSHUI)

Table .3- New Sewage Treatment Plant in Hebei province from 2012 to 2030 (Block)

city	2012	2013	2014	2015	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1																		
2				3														
3																		
4					1													
5					2	8	11											
6				37														
7																		
8						7												
9																		
10					4													
11																		

Table.4 shows the introduction of the number of new faucet subsidies, Hebei province need to introduce copper faucets in 2030, while lead the ceramic spool faucets in the rest of years.

Table.4- Introduction of New Domestic Faucets in HebeiProvince in 2012-2030 (10,000)

city	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	57									0.3	0.85					1.3	0.45	0.45	0.3
2	42								1.7	2.1		0.3				0.3	0.96	0.33	0.23
3	16.7	0.12	0.12										1.1		0.4	0.13	0.13		0.1
4	51	0.4								2.5	0.4					1.2	0.5		0.3
5	39.7	0.3	1.07							2		0.6	0.3	0.9		0.3	0.3		0.2
6	62.7	0.44								0.44		2.7	0.9			0.5	1.4	0.5	0.35
7	24.2	0.17								1.22		0.4	0.2			0.55	0.2	0.2	0.14
8	19.3	0.14								1			0.4			0.44	0.15	0.15	0.1
9	40	0.3								2		0.6	0.3			1	0.3		0.2
10	24.5	0.2								1.23			0.4			0.18	0.56	0.2	0.13
11	0.6	0.08	0.68									25	0.2			0.56	0.2	0.2	0.3

The financial subsidies for the new irrigation technologies in the municipalities of Hebei province are as follows(*Table .5)*.According to the simulation results, Hebei province only introduce the sprinkler technology[13-14]

Table .5- Application of New Irrigation Technology in Cities (10,000 hectares)

city	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1																			
2																			
3																			
4										6.2	6.9			6.7	6.9				
5																			
6				37															
7												5.7				6.8	6.9	7	
8																	6.8		
9				57												7	6.5		
10																			
11										6.2									

Hebei province in the next 20 years should vigorously develop low-pollution high value-added tertiary industry, limit industrial development[15] and develop green agriculture, ecological agriculture. In order to reach the 12th Five-Year Plan of water pollutant removal rate and water-saving targets,Hebeiprovince has to subsidize the new sewage treatment plants 8.7 billion RMB, subsidize for the introduction of household faucets 1.01 billion RMB, subsidize for the introduction of new irrigation technologys 11.03 billion RMB.Besides, Hebei province should adjust the industrial structure to 8:14:78 by2030.

Acknowledgements

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