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Surface Water Environmental Carrying Capacity in Water-Deficient Areas: A Case Study of the Beijing-Tianjin-Hebei Region and Five Northwestern Provinces (Autonomous Regions) of China

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Abstract: This paper discusses the environmental carrying capacity of surface water in various main functional zones in water-deficient areas such as the Beijing-Tianjin-Hebei (Jingjinji) region and the five northwestern provinces and autonomous regions of China. Main function was used as the basic principle to divide the control unit. This study analyzed the pollution-bearing capacity of the main functional zones and the pollutant discharge statistics from the Ministry of Environmental Protection. The results show that ammonia discharge due to emissions from urban activities in the Developing Areas (Dev-areas) of Jingjinji and northwestern China is greater than the surface water environmental carrying capacity of those regions. Pollutant discharge, including chemical oxygen demand (COD) and ammonia, in the Major Agricultural Product-Producing Areas (Agr-areas) and the Key Protected Ecological Areas (Eco-areas) overloaded the capacity of the Jingjinji region; 19%–73% of surface water environmental carrying capacity remained in the five northwestern provinces and autonomous regions in China. Therefore, environmental and industrial policies for various main functional zones should depend on the type of functional zone and the overload degree of surface water environmental carrying capacity.

Keywords: water-deficient areas; environmental water capacity; main functional zone; overload degree

1 Background

Water resources are basic natural resources and strategic economic resources, as well as controlling factors for the ecological environment, and they play an important role in sustainable economic development and the construction of ecological civilizations in regional societies.

The gross amount of water resources in China ranks sixth overall in the world; however, the amount of water resources per capita and per mu accounts for only 28% and 50% of the world average, respectively. Additionally, water resources are distributed more in the south and less in the north, more in the east and less in the west, more in the mountains and less in the plains. The natural endowment of water resources, thus, cannot match the population, land, cultivated land resources, or allocation of productive force [1]. Based on the general international standard (the report standard of *Sustaining Water-Population and the Future of Renewable Water Supplies*, proposed in the International Population Action in 1993), water use is strained in 14 provinces and cities of China (Beijing, Tianjin, Hebei, Shanxi, Shanghai, Jiangsu, Shandong, Henan, Ningxia, Liaoning, Jilin, Anhui, Shaanxi, and Gansu). These regions lacking water resources are

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also weak in population, economy, cultivated land, and ecology, with an obvious imbalance between the supply and demand of water resources, which are in great discord with the water demands of production, agricultural land, and the regional ecological environment of the regions. First, a discord between water resources and the allocation of a productive force is reflected mainly in North China, where the gross amount of water resources accounts for only 3% of China's total, but GDP accounts for 15% of the national total. Second, the discord between water resources and cultivated land resources is reflected mainly in the Northwest, the Northeast, and North China, where total cultivated land area accounts for 32% of the national total but gross amount of water resources accounts only for 9%. Third, spatial distribution of water resources is in discord with the water demands of the ecological environment; the water yield per unit area in the Northwest and North China is far below the average level. Additionally, these provinces and cities are located in arid or semiarid regions in the north, where the water demands of the ecological environment are great. The shortage of water resources intensifies the ecological environmental problem already very apparent in these regions, which may affect regional sustainable development [2]. Analysis of the surface water environment capacity and the current situation of bearing capacity in the regions lacking water resources contributes to improvement of water ecology and the economic/social development layout of the regions.

The top priority in constructing an ecological civilization is to optimize the national land space exploitation pattern, the strategic focus of which lies in implementing the strategy for and forming the layout of main functional zones [3,4]. The State Council issued the *Main Functional Zones Planning* (GF [2010] No. 46) directives in 2010, which classifies the national land space of China by development mode into Optimized Developing Areas, Major Developing Areas, Restricted Developing Areas, and Prohibited Developing Areas, as well as by development focus into Urbanization Areas (Urb-areas), Major Agricultural Product-Producing Areas (Agr-areas), and Key Protected Ecological Areas (Eco-areas). It proposes to promote development in accordance with the main functional objectives based on development orientation and control based on main functional orientation. In the Urb-areas, the top priority is to enhance comprehensive economic strength, while simultaneously protecting the cultivated land and ecological environment. In the Agr-areas, the top priority is to enhance comprehensive agricultural productivity while simultaneously protecting the ecological environment, so as to develop non-agricultural industries moderately without affecting the main function. In the Eco-areas, the top priority is to enhance ability to supply ecological products, and to develop suitable industries moderately without affecting the main functions [5]. Thus far, major function regionalization has informed the strategic, basic, and restricted planning for China's utilization of national land space, and construction of the main functional zones has become an important strategic measure to carry out a national land space development pattern that maintains harmony between population, economy, resources, and the environment. In the 13th Five-Year Plan, construction of the main functional zones is considered a new strategic height in implementing construction of an ecological civilization. The key factor in forming the new modernization construction pattern with harmonious development of human and nature is determining how to integrate promotion of ecological civilization and green economic development into construction of the main functional zones [4].

With respect to water environmental capacity, taking the Beijing-Tianjin-Hebei (Jingjinji) region and five northwestern provinces and autonomous regions in China as representative regions with the most obvious imbalances between supply and demand of water resources, this study analyzed the utilization/overload conditions of the water environment capacity of various main functional zones, so as to give suggestions on use of water resources and water environment protection in different functional zones of these regions.

2 Research methods

2.1 Overview of research areas

The Jingjinji region is the most lacking in national water resources, with the most severe water pollution and water ecology degeneration as well as the sharpest contradiction between support force and development of the water environment. With 2.3% of the national land area and 1% of China's water resources, the Jingjinji region contributes to 9.7% of China's GDP, and has 8.1% of its population, with chemical oxygen demand (COD) and ammonia nitrogen emissions accounting for 7% and 6%, respectively [6,7] (Table 1). In 157 water functional areas, only 26% surface water is of an acceptable quality [8]. The overall orientation of the Jingjinji region is "the world-class city group centered on the capital, the leading region of overall coordinated development of areas, the new engine of China with innovation driving economic growth and the demonstration area of ecological restoration and environmental improvement." In development of the region, overall planning intends to solve problems concerning economy, ecology, and transportation, and to facilitate integrated construction and improvement of human settlement in the region [5,9].

With 43% of the national land area and 8% of national water resources, the five northwestern provinces and autonomous regions contribute to 6% of China's GDP and account for 6% of its population, with COD and ammonia nitrogen emissions accounting for 10% and 7%, respectively. In 502 water functional areas, only 51% of surface water is of acceptable quality [8] (Table 1). The five northwestern provinces and autonomous regions have great ecological value and strategic importance in

China. As supported by major strategies such as the develop-the-west strategy and the strategic conception of the New Silk Road Economic Zone, they will play an increasingly important role, and rapid, sustainable economic development will gradually narrow the discrepancy in these areas from China's average development level.

2.2 Control unit classification method

This study intends to effectively combine the environmental capacity and pollutant emission data of the water functional areas in various main functional zones and give suggestions regarding the analysis and development of water environment capacity utilization/overload in different regions. To this end, the study classifies control units at three levels in the Jingjinji region and the five northwestern provinces and autonomous regions based on the principle of the strategic, basic, and restricted planning of major function regionalization for national land space use, issued by the National Development and Reform Commission. It additionally integrates factors such as comprehensive main functional zones, administrative regions, water ecology regionalization, water system integrity, water quality responses, and water functional area integrity.

The level-1 control unit refers to four types of main functional zones, related primarily to the scope and types of major function regionalization. The level-2 control unit is called the control region (the Jingjinji region has 12 control regions, and the five northwestern provinces and autonomous regions have 10), in which factors such as water ecology regionalization and administrative region are considered to analyze environmental capacity and pollutant emissions. Level-2 control units are classified with different emphasis according to functional area type: for Optimized Developing Areas, differences in economic/social characteristics are considered; for Major Developing Areas, differences in spatial position are considered; for Agr-areas, differences in ecological function zoning are considered; for Eco-areas, differences water ecology function regionalization are considered. The level-3 control unit refers to the sub-control regions (the Jingjinji region has 29 sub-control regions, and the five northwestern provinces and autonomous regions have 24), for which drainage basin integrity is primarily considered. See Fig. 1 for classification of the control units in the Jingjinji region and the five northwestern provinces and autonomous regions.

2.3 Water environmental capacity calculation method

Water environmental capacity refers to the quantity of pollutants that can be contained in a water environment under a given environmental objective, and relates to water characteristics, water quality objectives, and pollutant characteristics and emission patterns [10]. With the change in focus of the water environment management system from concentration control and total target control to total capacity control, water quality target management and water pollutant limits based on calculation of the water environmental capacity are growing ever more important [11–13]. Data on water quality and quantity in water functional areas are collected according to the *Technical Outline for Assimilative Capacity Check and Total Quantity Control Scheme for Phased Controlled Drainage of Water Functional Areas in Important Rivers and Lakes of China*, so as to conduct water quality assessment of the water functional area in the base year. Based on work related to general investigation of pollution discharge outlets for rivers in all drainage basins, a statistical survey on pollution discharge outlets and tributary inlets of rivers in water functional areas of important rivers and lakes was conducted to determine the current amount of main pollutants entering the water functional areas. According to the water quality objective requirements for the water functional areas in important rivers

Table 1. Overview of research areas.

Region		Area ($\times10^4$ km^2)	Population ($\times10^4$ persons)	GDP (100 million yuan)	Industrial sector (100 million yuan)	Water resources ($\times10^8$ m^3)	Compliance rate in water functional area (%)	COD emissions ($\times10^4$ t)	Ammonia nitrogen emissions ($\times10^4$ t)
Jingjinji	Beijing	1.6	2 152	21 331	3 747	20	41	17	2
	Tianjin	1.2	1 517	15 727	7 079	11	6	21	2
	Hebei	19	7 384	29 421	13 331	106	33	127	10
	Percentage of national total (%)	2.3	8.1	9.7	11	1	1.95	7	6
Five northwestern provinces (autonomous regions)	Inner Mongolia	118	2 505	17 770	7 904	538	23	85	4.9
	Gansu	45	2 591	6 837	2 263	198	71	37	3.8
	Qinghai	72	583	2 303	954	793	82	11	1.0
	Ningxia	7	662	2 752	973	10	57	22	1.7
	Xinjiang	166	2 298	9 273	3 179	726	89	67	4.6
	Percentage of national total (%)	43	6	6	7	8	11.9	10	7

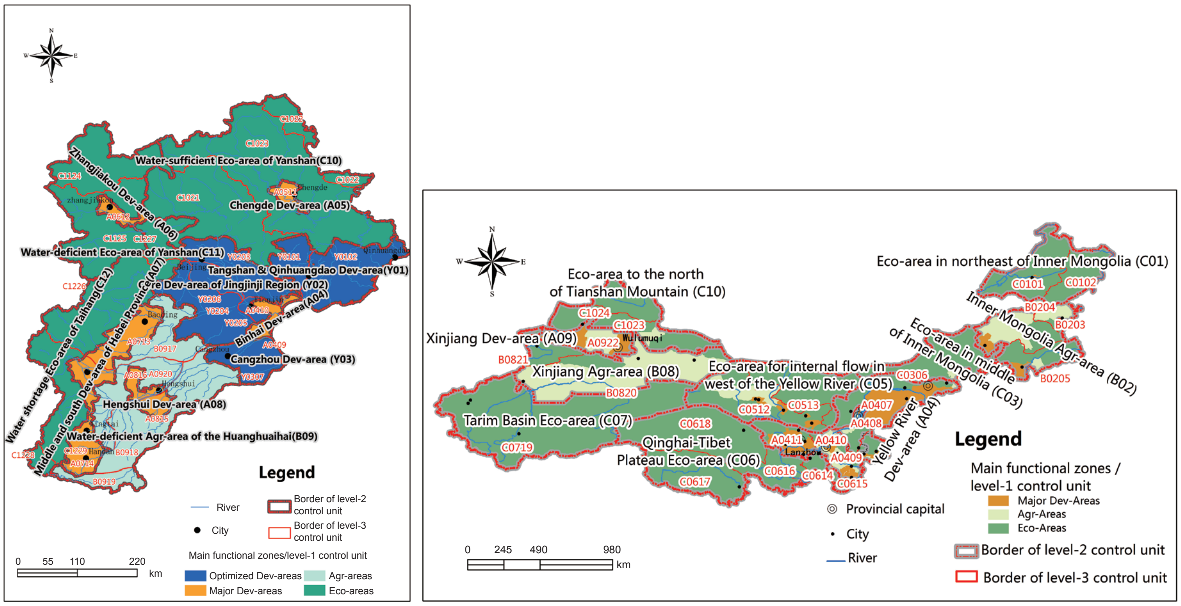

Fig. 1. Control unit classification at the three levels in the Jingjinji region and the five northwestern provinces and autonomous regions.

and lakes of China, the assimilative capacity (water environmental capacity) of the water functional areas in important rivers and lakes was rechecked, with emphasis placed on the assimilative capacity of the water functional areas with adjusted water quality objectives or changes in design conditions (such as flow). Based on this recheck of the assimilative capacity of the water area, as well as measurement and calculation of the amount of main pollutants entering the river, quantity control of pollution discharge in the water functional area can be determined. Taking the control units at each of the three levels (main functional zones, control regions, and sub-control regions), the pollutant discharge of different areas was analyzed to provide relevant suggestions.

2.4 Major data sources

Data on the main functional zones are taken from the *Main Functional Zones Planning* (GF [2010] No. 46) directive issued by the National Development and Reform Commission and the people's governments of related provinces [5,9]. The data on assimilative capacity (environmental capacity) of the water area of the water functional area are taken from the *National Water Resource Protection Planning (2015–2030)* directive issued by the Ministry of Water Resources [8]. The pollutant discharge data for counties and cities are taken from the environmental statistical data of the Ministry of Environmental Protection (2014) [7].

3 Main results and analysis

3.1 Water environmental capacity and overload of pollutants into rivers in Jingjinji

In the Jingjinji region, the COD capacity of the surface water environment is 57468 t/a, and the amount of COD introduced into the river (83929 t/a) is 1.5 times the capacity; the ammonia nitrogen capacity is 2806 t/a, and the amount of ammonia nitrogen introduced into the river (12354 t/a) is 4.4 times the capacity. See Table 2 for environmental capacity and pollutant discharge overload of the various main functional zones and control regions in the Jingjinji region.

For COD, among the four types of main functional zones the Major Developing Areas have the maximum emissions of COD into the river, with 68% of water functional areas in an overloaded condition. Optimized Developing Areas have a 38% overload ratio of total COD into the river, and the overload ratio of the water functional area is 22%. For Agr-areas and Eco-areas, the total amount of COD into river is relatively higher than capacity, but the ratio of water functional areas with overload is 20%. Ammonia nitrogen emissions show conditions similar to those of COD. The Major Developing Areas have the maximum amount of ammonia nitrogen emissions into the river; 67% of water functional areas in an overloaded condition and the total amount of pollutants introduced into the river is 6.1 times capacity. For Optimized Developing Areas, the total amount of ammonia nitrogen introduced into the river is 3.1 times capacity, and the overload ratio of water functional areas is 27%. For Agr-areas and Eco-areas, the total amount of ammonia nitrogen introduced into the river is below capacity, and the total overload is 1.3 times and 1.9 times, respectively, but the ratio of water functional areas with overload reaches 20%.

The overload of pollutants into the river shows great differences in the control regions (level-2 control unit) (Fig. 2). With respect to the three control regions of the Optimized Developing Areas, the amount of pollutants introduced into river is close to the environment capacity in the Tangshan and Qinhuangdao ar-

Table 2. Environmental capacity and overload of pollutants into the river for COD and ammonia nitrogen in Jingjinji, based on water quality objectives of the water functional area.

Control unit	Quantity of water functional areas	Water quality objective				COD (t/a)		Ammonia nitrogen (t/a)	
		II	III	IV	V	Capacity	Overload of pollutants into river	Capacity	Overload of pollutants into river
Optimized Developing Areas (Y)	32	2	8	19	3	26 383	10 147	1 258	3 927
Tangshan and Qinhuangdao area (Y01)	6	0	3	3	0	18 257	−269	908	140
Core area of Jingjinji region (Y02)	18	1	4	11	2	4 998	6 345	198	2 785
Cangzhou area (Y03)	8	1	1	5	1	3 128	4 071	152	1 002
Major Developing Areas (A)	15	1	6	7	1	15 869	15 823	735	4 481
Binhai Development Zone (A04)	0	0	0	0	0	0	0	0	0
Chengde area (A05)	1	0	1	0	0	3 411	197	151	1 505
Zhangjiakou area (A06)	2	0	1	1	0	3 098	984	147	180
Middle and southern areas of Hebei Province (Baoding/Shijiazhuang/Xingtai/Handan) (A07)	6	1	2	2	1	6 411	4 197	306	1 535
Hengshui area (A08)	6	0	2	4	0	2 948	10 445	131	1 261
Major Agricultural Product-Producing Areas (B)	18	1	7	10	0	3 593	732	169	319
Water deficient area of Huanghuaihai Plain (B09)	18	1	7	10	0	3 593	732	169	319
Key Protected Ecological Areas (C)	51	26	21	3	1	11 623	−241	644	821
Water sufficient area of Yanshan Mountain region (C10)	33	17	14	1	1	5 674	2 754	313	515
Water deficient area of Yanshan Mountain region (C11)	7	1	4	2	0	4 715	−3 041	217	316
Water shortage area of Taihang Mountain region (C12)	11	8	3	0	0	1 235	46	114	−10
Total	116	30	42	39	5	57 468	26 461	2 806	9 548

eas, and the ammonia nitrogen overload into the river is 14 times capacity in the Beijing, Tianjin, and Langfang regions. In the Major Developing Areas, the Hengshui area has the most severe overload, with COD at 3.5 times capacity and ammonia nitrogen at 9.6 times capacity; in the Chengde area, the ammonia nitrogen overload into the river is 10 times capacity; in the middle and southern areas of Hebei Province, the ammonia nitrogen overload into the river is 5 times capacity. In the Eco-areas, the water sufficient area of Yanshan Mountain region has both a large environmental capacity and a high overload of pollutants into the river; the COD overload ration is 50% , and the ammonia nitrogen overload is 1.6 times capacity. The COD capacity surplus is distributed in the water deficient area of the Yanshan Mountain region and the water shortage area of the Taihang Mountain region, whereas the ammonia nitrogen capacity surplus is distributed only in the water shortage area of the Taihang Mountain region.

3.2 Pollutant discharge of Jingjinji

In the Jingjinji region, COD emissions are centered primarily in agriculture (65%), and ammonia nitrogen emissions are centered primarily in urban life (54%). Given that national COD emissions are gradually controlled and the inflection point shows, ammonia nitrogen will be the key and challenging factor in pollution control in the Optimized Developing Areas (Table 3). The total emissions of ammonia nitrogen are highest in urban life, and a related major emission area is the core area of the Jingjinji region. Agricultural ammonia nitrogen emissions are highest in the core area of the Jingjinji region and the Agr-areas. Industrial ammonia nitrogen emissions are centered in the middle and southern urban belt of Hebei Province.

The industry analysis indicates that close attention should be paid to six industries in the Jingjinji region—petrifaction, papermaking, food, spinning, pharmaceutical, and leather—based on the ratios of industrial output value, wastewater discharge, and pollutant emissions. These six industries amount for 63% of wastewater discharge, 70% of COD emissions, and 73% of ammonia nitrogen emissions (Table 4). Regarding industrial COD emissions, close attention should be paid to the papermaking, petrifaction, and food industries, which account for 21%, 16%, and 14% of total industrial COD emissions, respectively. Regarding industrial ammonia nitrogen emissions, close attention should be paid to the petrifaction, papermaking, and food industries, which account for 35%, 11%, and 10% of total industrial ammonia nitrogen emissions, respectively.

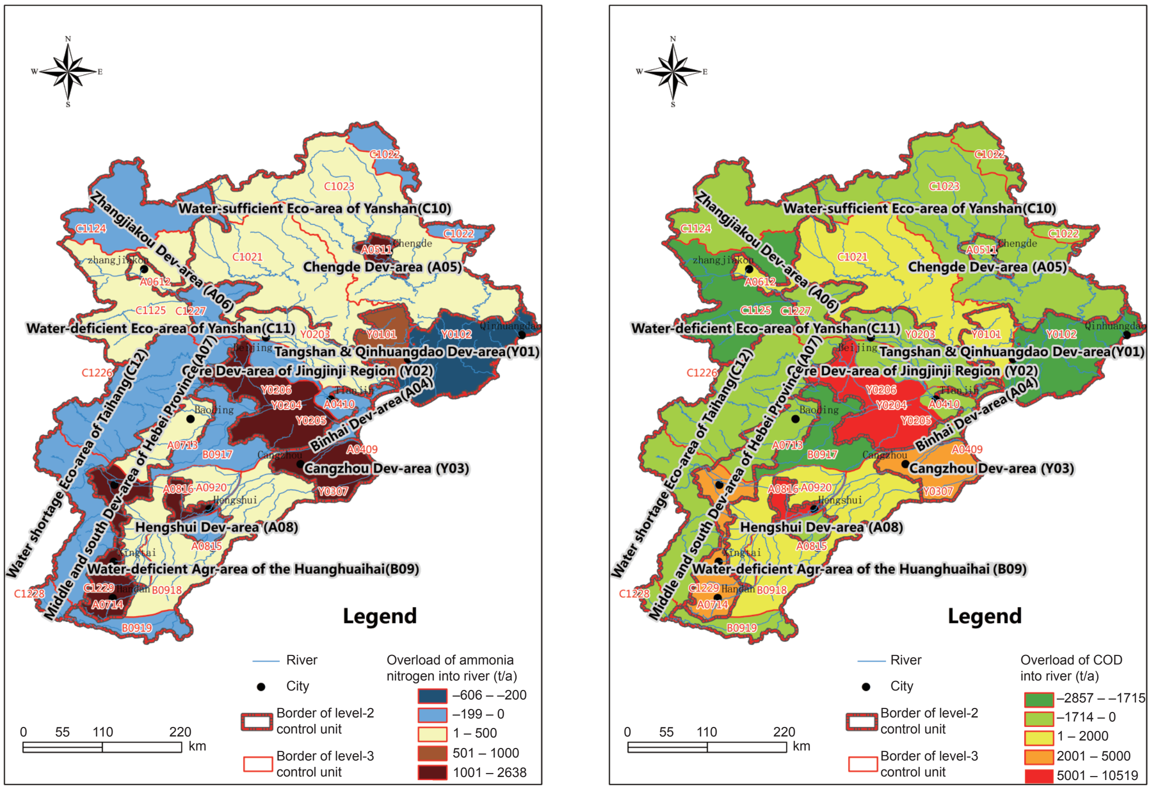

Fig. 2. Overload of pollutants into rivers of various control units of Jingjinji.

Table 3. COD and ammonia nitrogen emissions in various main functional zones of Jingjinji.

Main functional area	Emission of COD				Emission of ammonia nitrogen			
	Agricultural emissions (%)	Urban emissions (%)	Industrial emissions (%)	Total emissions (t/a)	Agricultural emissions (%)	Urban emissions (%)	Industrial emissions (%)	Total emissions (t/a)
Optimized Developing Areas	65	27	8	559 292	36	58	6	52 792
Major Developing Areas	54	29	17	302 894	21	57	22	32 352
Major Agricultural Product-Producing Areas	66	20	14	300 278	44	47	9	25 996
Key Protected Ecological Areas	75	18	7	331 743	47	46	7	23 301
Total	65	24	11	1 494 207	36	54	10	134 441

Table 4. Emission of main industrial pollutants in the Jingjinji region.

Industry	Wastewater discharge		Emission of COD		Emission of ammonia nitrogen	
	Total amount ($\times 10^4$ t/a)	Ratio (%)	Total amount (t/a)	Ratio (%)	Total amount (t/a)	Ratio (%)
Petrifaction	19 648	17	27 487	16	5 023	35
Papermaking	19 270	17	35 202	21	1 596	11
Food	11 454	10	22 554	14	1 491	10
Spinning	10 171	9	14 035	8	1 035	7
Pharmaceutical	5 200	5	9 414	6	1 054	7
Leather	5 129	5	8 791	5	491	3
Total	70 872	63	117 483	70	10 690	73

For the Jingjinji region, the major control industries of the various main functional zones are as follows: for the Optimized Developing Areas, the papermaking and food industries; for the Major Developing Areas, the chemical industry in the Binhai Dev-Area, the papermaking and pharmaceutical industries in the middle and southern urban belt of Hebei Province, and the leather industry in the Xinji region.

3.3 Water environmental capacity and overload of pollutants into rivers in five northwestern provinces and autonomous regions

For the surface water of the five northwestern provinces and autonomous regions, COD capacity is 9.72×10^4 t and ammonia nitrogen capacity is 4.48×10^4 t (Table 5). The degree of general utilization of the environmental capacity is not high; COD capacity utilization is only 38%, whereas ammonia nitrogen capacity utilization reaches 87%. Only the ammonia nitrogen emissions (2.76×10^4 t) of the Major Developing Areas exceeds the surface water environmental capacity (2.72×10^4 t).

See Fig. 3 and Fig. 4 for the spatial distribution of utilization of surface water COD and ammonia nitrogen capacity in the five northwestern provinces and autonomous regions. The areas with overload of pollutants into the river differ with respect to COD and ammonia nitrogen emissions. For COD, only three control units show overload, with the highest being 2.8 times capacity; for ammonia nitrogen, five control units show overload, with the highest being 5.7 times capacity. The Yellow River–Gansu Weihe River control unit (A0409), in a Major Developing Area, has 100%–150% COD overload. Control units with 150%–280% overload are mainly distributed in the Agr-area Inner Mongolia–Inner Mongolia internal flow control unit (B0204) and the Eco-area Tarim Basin–Tarim River internal flow control unit (C0719), which have excessive emissions of 3053 t/a (189%) and 5316 t/a (276%), respectively. Control units with 100%–150% ammonia nitrogen overload are mainly distributed in the mainstream areas of the Yellow River in Ningxia and Inner Mongolia: the Yellow River–Inner Mongolia unit (A0407) and Yellow River–Ningxia unit (A0408), both in Major Developing Areas; and the Eco-area Qinghai-Tibet Plateau–Gansu Yellow River mainstream unit (C0614). Control units with 150%–280% overload of ammonia nitrogen are mainly distributed in the Major Developing Areas: the Yellow River–Gansu Weihe River unit (A0409) and Yellow River–Qinghai Yellow River mainstream unit (A0411) have excessive emissions of 1652 t/a (261%) and 1229 t/a (194%), respectively.

Table 5. Surface water environmental capacity and overload volume of all main functional zones and control regions in the five northwestern provinces and autonomous regions.

Control unit	Water quality standard in water functional areas					COD (t/a)		Ammonia nitrogen (t/a)	
	Total	II	III	IV	V	Capacity	Overload of pollutants into river	Capacity	Overload of pollutants into river
Major Developing Areas (A)	94	21	51	22	0	60.5	–35	27 168	426
Yellow River Dev-area (A04)	85	15	48	22	0	60.0	–35	26 797	426
Xinjiang Dev-area (A09)	9	6	3	0	0	0.5	0	371	0
Major Agricultural Product-Producing Areas (B)	123	39	46	36	2	22.0	–4.4	12 492	–5 298
Inner Mongolia Agr-area (B02)	93	26	32	33	2	6.8	–2.4	7 067	–1 924
Xinjiang Agr-area (B08)	30	13	14	3	0	15.2	–12	5 426	–3 374
Key Protected Ecological Areas (C)	136	78	51	7	0	14.7	–11	5 167	–1 059
Northeast Inner Mongolia Eco-area(C01)	59	30	23	6	0	5.5	–2.9	2 631	378
Middle Inner Mongolia Eco-area (C03)	4	1	3	0	0	0.0	0	0	0
Eco-area for internal flow west of the Yellow River (C05)	14	4	9	1	0	4.2	–3.7	868	–202
Qinghai-Tibet Plateau Eco-area (C06)	29	18	11	0	0	1.6	–1.2	798	–283
Tarim Basin Eco-area (C07)	12	8	4	0	0	0.2	0.3	82	–5
Eco-area north of Tianshan Mountain (C10)	18	17	1	0	0	3.2	–3.6	788	–937
Total	354	138	148	65	2	97.2	–60.4	44 827	–5 931

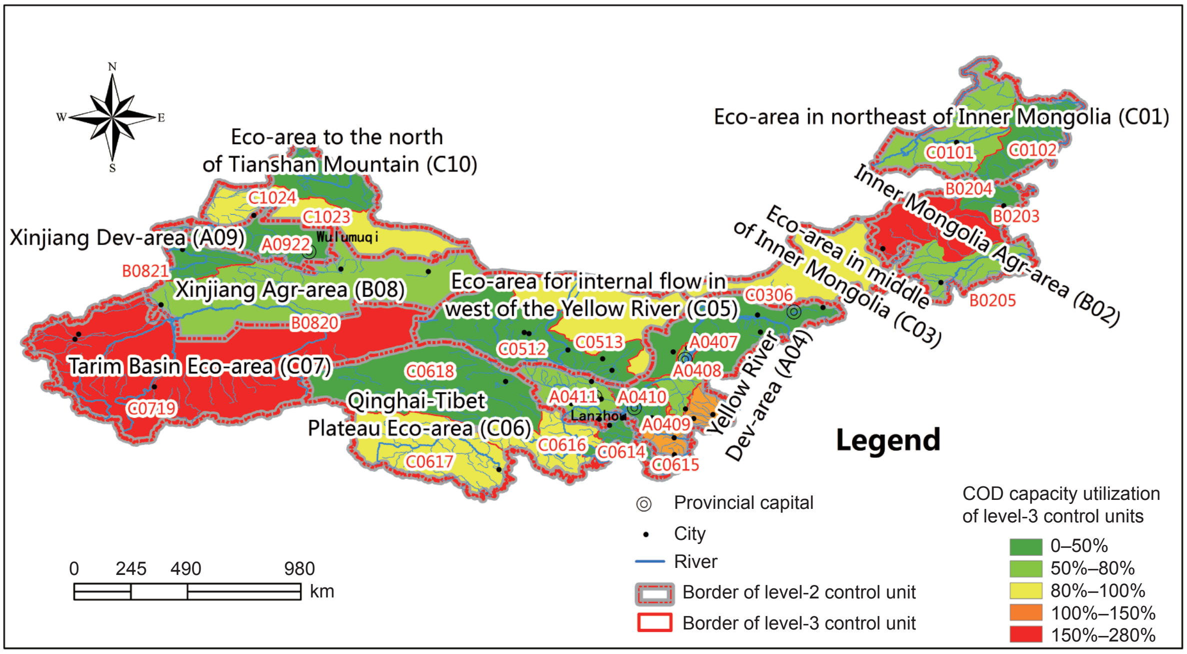

Fig. 3. COD capacity utilization of control units at the three levels in the five northwestern provinces and autonomous regions.

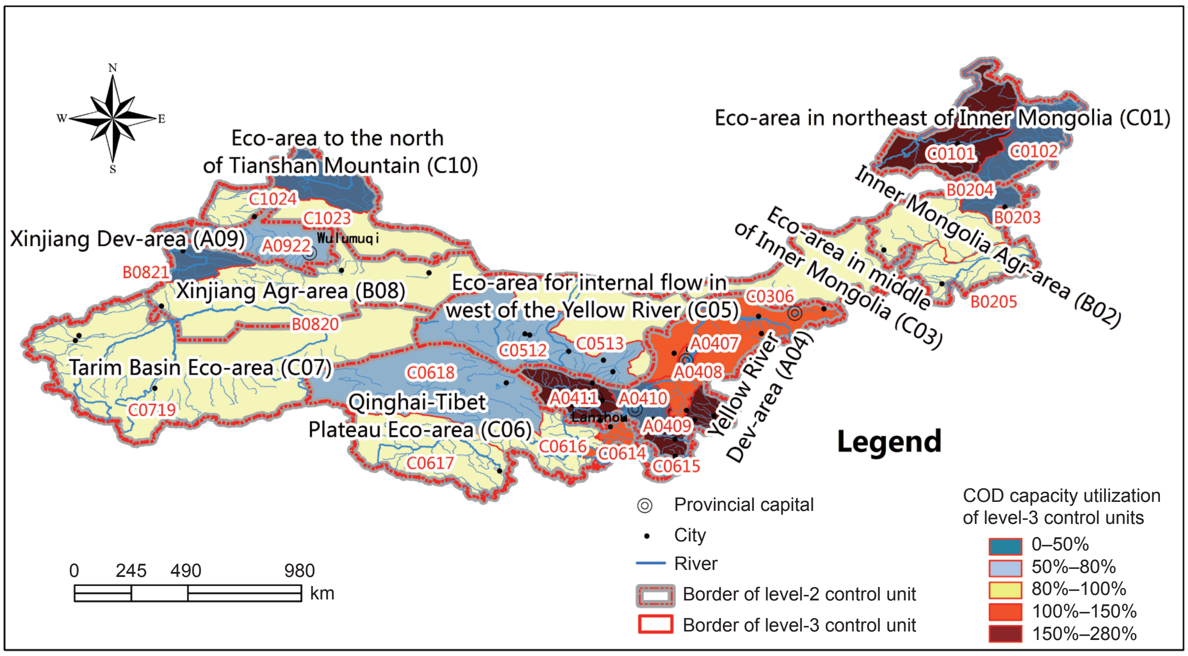

Fig. 4. Ammonia nitrogen capacity utilization of control units at the three levels in the five northwestern provinces and autonomous regions.

3.4 Pollutant discharge conditions of the five northwestern provinces and autonomous regions

According to the analysis of the land-based pollution source discharge of the five northwestern provinces and autonomous regions, the pollutant discharge is centered primarily in the Major Developing Areas of the main functional zones. With respect to distribution of agricultural pollutant emission, urban life pollutant emission, and industrial pollutant emission, COD emissions are centered in agriculture (55 %) and ammonia nitrogen emissions are centered in urban life (53 %) (Table 6). Close attention should be paid to urban life pollutant emissions, especially to the ammonia nitrogen emissions of all five northwestern provinces and autonomous regions, as well as the COD emissions of the Major Developing Areas.

With respect to COD emissions, close attention should be paid to the Eco-areas, the Agr-areas, and the Yellow River developing areas in northeast Inner Mongolia. In the Agr-area Inner

Table 6. Types of COD and ammonia nitrogen emissions in main functional zones of the five northwestern provinces and autonomous regions.

Main functional area	Emission of COD				Emission of ammonia nitrogen			
	Agricultural emissions (%)	Urban emissions (%)	Industrial emissions (%)	Total emissions (t/a)	Agricultural emissions (%)	Urban emissions (%)	Industrial emissions (%)	Total emissions (t/a)
Major Developing Areas	45	30	25	935870	15	58	27	80651
Major Agricultural Product-Producing Areas	60	14	26	532087	26	48	26	34356
Key Protected Ecological Areas	69	19	13	626036	23	49	28	38386
Total	55	23	22	2093993	20	53	27	153393

Mongolia–Inner Mongolia internal flow control unit (B0204) and in the Eco-area Tarim Basin–Tarim River internal flow control unit (C0719) (which have a COD capacity utilization of 189% and 276%, respectively), agricultural emissions account for 87% and 79%, respectively. Therefore, these are the key emission reduction areas. With respect to ammonia nitrogen emissions, the Yellow River developing area has the maximum total emission (emission of ammonia nitrogen from urban life accounts for 58%). In the Yellow River–Gansu Weihe River control unit (A0409) and the Yellow River–Qinghai Yellow River mainstream control unit (A0411) (both in Major Developing Areas, with ammonia nitrogen capacity utilization of 261% and 194%, respectively), urban emissions account for 73% and 80%, respectively. Therefore, these are the key emission reduction areas.

Industry analysis indicates that close attention should be paid to six industries—metal smelting, mining, petrifaction, chemical, food, and papermaking—based on the ratios of industrial output value, wastewater discharge, and pollutant emissions. These six industries account for 73% of output, 87% of wastewater discharge, COD emissions of 92%, and ammonia nitrogen emissions of 95%. With respect to industrial COD emissions, close attention should be paid to the chemical, food, and papermaking industries, which account for 36%, 26%, and 15% of total industrial COD emissions, respectively. With respect to industrial ammonia nitrogen emissions, close attention should be paid to the chemical, petrifaction, food, and metal smelting industries, which account for 45%, 16%, 13%, and 12% of total industrial ammonia nitrogen emissions, respectively.

4 Conclusions and Recommendations

(1) Surface water ammonia nitrogen capacity in Major Developing Areas is in a severely overloaded condition, centered primarily in ammonia nitrogen emissions from urban life. Therefore, sewage collection rate and ammonia nitrogen emission standards should be improved further. The Major Agricultural Product-Producing Areas (Agr-areas) and Key Protected Ecological Areas (Eco-areas) also have overloaded surface water environmental capacity. In the Jingjinji region, COD and ammonia nitrogen introduced into the river are in overloaded conditions; in the five northwestern provinces and autonomous regions, 19%–73% of environmental capacity is surplus. In addition to further controlling industrial and urban life emissions, control of pollution caused by agriculture, livestock breeding, and so on should be strengthened.

(2) The six major pollutant-emitting industries in the Jingjinji region include the petrifaction, papermaking, food, spinning, pharmaceutical, and leather industries. According to pollutant emissions per 100 million yuan GDP, the strategy of closing and transferring the entire industry should be implemented for the spinning industry, the leather industry, and the papermaking industry (COD: 49–66 t/100 million yuan; ammonia nitrogen: 2.2–4.9 t/100 million yuan); measures such as closing and transferring the entire industry, transforming industrial clean production, and improving wastewater treatment processes may be implemented for the petrifaction industry, the food industry, and the pharmaceutical industry (COD: 10–15 t/100 million yuan; ammonia nitrogen: 1–2 t/100 million yuan). For the pharmaceutical industry, which discharges only 16% of wastewater into surface water directly, transforming industrial clean production and improving wastewater treatment processes should be the most important objectives for development.

(3) In the five northwestern provinces and autonomous regions, environmental capacity is underutilized. In the Major Developing Areas, measures such as transforming industrial clean production and improving wastewater treatment processes should be implemented to promote reduction in industrial pollution emissions, and industries with high water resource utilization should be developed moderately. In the Agr-areas, close attention should be paid to agricultural water preservation, as well as to urban life and livestock breeding. In the Eco-areas, development of economic industries conforming to the main function planning directives should be accelerated.

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