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Study on characteristics of water resources in Beijing in recent 15 years

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Abstract. In order to understand the characteristics of water supply and water usage in Beijing in recent 15 years, a variety of statistical datasets were collected and field investigations were carried out, to analyze the total water resource, the characteristics and trends of water resource supply, utilization and distribution during 2000-2014. The results showed that the total amount of water resources in Beijing is maintained at 1.61~3.95 billion m³, and the surface water accounts for about 1/3, and the groundwater accounts for 2/3. Agricultural water and living water were the dominated consumption in the past 15 years in Beijing, accounted for 35.3% and 38.9% of the total amount, followed by industrial water, which accounting for 17.9% of total water consumption, and water used in environment is relatively small, only accounting for 7.8% of the total amount. This study can provide theoretical support for the establishment and management of water conservation policies and the rational utilization of water resources in Beijing.

1. Introduction

Water resources are widely used by human beings in production and life activities, not only including usage in agriculture, industry and life, but also for power generation, water transportation, aquatic products, tourism and environmental transformation and so on. Suitable water resources quantity, high water quality, and uniform of the spatial and temporal distribution will make great contributions to the regional economic development, the virtuous cycle of the natural environment and the progress of human society. Improper exploitation and utilization of water resources can restrict the development of national economy and destroy the living environment of human beings. Therefore, the former research on water resources has gradually increased, mainly in the use efficiency of water resources [1], spatial-temporal distribution and comprehensive evaluation [2], optimal allocation of water resources [3], influencing factors and effective management of water resources, evaluation of water resources carrying capacity and other aspects of water resources.

Beijing region is in the middle ecological fragile area, and the contradiction between supply and demand of water resources and social economic development is very prominent. Beijing city is short of water resources, and the city's per capita water resources is less than 300 m³, which is 1/8 of the national per capita, and 1/30 of the world average value, also far below the water shortage limit standard of the internationally recognized 1000 m³ per capita[4].

The water consumption in Beijing is affected by industrial production, people's living, environment greening, agricultural planting area, planting structure and other factors, in the end resulting in the changes of the quantity of water supply and water consumption [5]. In order to make clear understanding of the water supply and water variation characteristics in recent 15 years in Beijing, a



variety of statistical datasets were collected and investigations were implemented to study the supply and utilization of water resources, the distribution characteristics and changing trend of configuration in the year of 2000-2014, to provide theoretical support for the rational utilization of water resources in Beijing.

2. Materials and methods

Based on the "Beijing water resources bulletin", which published by the Beijing Municipal Water Affairs Bureau, this study will analyze the water supply and water usage characteristics in recent 15 years in Beijing city, including surface water resources, groundwater resources, reuse water, total water resources, total water consumption, and water distribution in living, environment, industrial and agriculture. The collected data were statistically analyzed based on Excel 2010.

3. Results

3.1. Characteristics of water supply in Beijing

During the period of 2000-2014, except for 1.279 billion m^3 in 2008 and 1.795 billion m^3 in 2012, the amount of surface water resources in other years are lower than 1 billion m^3 , and mainly maintained in 525~943 million m^3 .

The overall amount of groundwater resources in Beijing city is much higher than the amount of surface water resources, except for 2.142 billion m^3 in 2008 and 2.155 billion m^3 in 2012, the amount of groundwater resources in other years are in the ranges of 1.38~1.846 billion m^3 .

The total amount of water resources is mainly maintained at 1.611~3.95 billion m^3 , showing the same changing trend with the surface and groundwater resources, and surface water accounts for about 1/3, while groundwater accounts for about 2/3. Per capita water resources is between 94.9~198.5 m^3 , which is far below the internationally recognized water shortage warning line of 1000 cubic meters per capita, so Beijing is becoming one of the largest water shortage in China's big cities.

3.2. Present situation of water resources supply and allocation

The total water supply in Beijing in 2000 was the highest in the past 15 years, which up to 4.04 billion m^3 . The water supply amount of surface water resources is 1.335 billion m^3 , accounting for 33% of the total water supply; the groundwater supply is 2.708 billion m^3 , accounting for 66.9% of the total water supply. In 2001, the city's water supply in Beijing was 3.89 billion m^3 , which was 147 million m^3 lower than that of 2000. After that, the total water supply of the city was maintained between 3.43~3.75 billion m^3 . Water supply is mainly supplied by surface water and groundwater in 2000~2002, of which surface water supply accounts for about 1/3, and groundwater supply accounts for about 2/3.

From the year 2003, Beijing make the reused water allocated into the city's annual water resources for unified deployment, and then due to the increase use of recycled water, to some extent, it alleviate the burden of surface water and groundwater, so the surface water and groundwater supply gradually reduced. In 2003~2007, the surface water supply accounted for 16.3%~23.3% of the total supply, the proportion of groundwater supply was between 69.5%~77.6%, the proportion of recycled water supply to the total water supply was 5.7%~14.2%, and in 2014, the supply of reused water in Beijing reached 860 million m^3 . The reused water plays an important role in alleviating the shortage of water resources and becomes an indispensable water source for Beijing.

Since the year of 2008, the middle route of the South to North Water Diversion Project has been passed through Beijing-Shijiazhuang section, it has reduced the surface water and ground water consumption in Beijing. During 2008~2014, the total surface water supply accounts for 13.1%~22.7% of total water supply, and the total groundwater supply accounts for 52.3%~65.2%, the total reused water supply quantity accounts for 6.0%~8.6%, water supply from South to North Water Transfer Project accounts for 0.7%~3.5%. After the year 2008, the average proportion of surface water, groundwater, reused water and water transfer from South to North was 15.3%, 58.5%, 20% and 6.2%,

respectively. The proportion of reused water and the water transfer from South to North increased gradually, and the proportion of groundwater use decreased.

3.3. Characteristics of water usage in Beijing

The total water consumption in Beijing was 4.04 billion m³ in 2000. Among them, industrial water was 986 million m³, accounting for 24% of the total water consumption; living water was 1.06 billion m³, accounting for 26% of the total water consumption; agricultural water was 1.96 billion m³, accounting for 49% of total water consumption; environmental water was 43 million m³, accounting for 1% of the total water consumption.

In 2001, the total water consumption in Beijing was 3.89 billion m³, and then it was maintained at 3.43~3.75 billion m³, and the fluctuation range was not large. In the past years of 2000-2014, the consumption of industrial and agricultural in Beijing decreased year by year, and the living water and environmental water increased year by year. In 2005, the water consumption was basically balanced with the agricultural water consumption, and then the living water consumption was higher than the agricultural water consumption. By 2014, the total water consumption in Beijing was 3.75 billion m³, including 1.7 billion m³ of living water, 720 million m³ of environmental water, 510 million m³ of industrial water, and 820 million m³ of agricultural water.

From the view of overall distribution, in the nearly 15 years, the proportion of living water in Beijing increased from 26.3% in 2000 to 45.3% in 2014, environmental water increased from 0.77% to 19.2%, industrial water decreased from 24.4% in 2000 to 13.6% in 2014. Before 2005, agricultural water has been the absolute subject of water use in Beijing, higher than living water, industrial water and environmental water. Since 2005, the living water has become the main body of water consumption, and the proportion of agricultural water has been decreasing. The results showed that the proportion of agricultural water use decreased from 48.4% in 2000 to 21.9% in 2014, indicating a decrease in absolute quantity or proportion of agricultural water under the condition that the total water consumption remained stable.

In the past 15 years, the total water consumption in Beijing was dominated by agricultural water and domestic water, accounting for 35.3% and 38.9% of the total water consumption, followed by industrial water, which accounting for 17.9% of the total water consumption, and the environmental water consumption was relatively small, only accounting for 7.8% of the total water consumption.

4. Conclusions

The total amount of water resources in Beijing is maintained at 1.61~3.95 billion m³, the surface water accounts for about 1/3, and the groundwater accounts for 2/3. Agricultural water and living water were the dominated consumption in the past 15 years in Beijing, which accounting for 35.3% and 38.9% of the total amount, followed by industrial water, which accounting for 17.9% of total water consumption, and water used in environment is relatively small, only accounting for 7.8% of the total amount. This study can provide theoretical support for the establishment and management of water conservation policies, and the rational utilization of water resources in Beijing.

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