Review on the Impact of Groundwater Over-exploitation on Ecological Environment and its Management and Protection

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Abstract

Water resources are an important condition for maintaining life activities. With the rapid development of social economy, the demand for water resources in human society has increased rapidly, and the exploitation of water resources has also increased, resulting in the shortage of surface water resources. The mining has to be extended to the ground, and even in some arid and semi-arid areas, groundwater resources have become the main source of water. A certain amount of water stress has been alleviated within the scope of reasonable mining, bringing significant social and economic benefits to human society. However, the negative effects of various ecological environments caused by improper groundwater exploitation, such as depletion of groundwater resources, groundwater quality pollution, land subsidence, karst collapse, land desertification, etc., and other ecological and environmental problems are threatening the sustainable development of the economy and society, which needs to be resolved. This paper summarizes the contents of ecological environment problems caused by improper exploitation of groundwater and its countermeasures based on the collection of several relevant literatures.

Keywords

Groundwater over-exploitation, ecological environment problems, mining management, ecological protection.

1. Status of National Groundwater Development and Utilization

With the development of economy and society, the amount of groundwater exploitation is gradually increasing. In 1972, the amount of groundwater exploitation in the country was about 20 billion m3. After three years of rapid growth, it showed a slow growth from 1975 to 1985. After 1985, the amount of groundwater exploitation increased rapidly, reaching about 110 billion m3 in 2000, with an average annual growth of 30. Million m3; after 2000, the amount of groundwater extraction has entered a stable period, maintaining a range of 100.2 billion to 133.4 billion m3, of which groundwater extraction was the smallest in 2003 and the largest in 2012. The amount of groundwater extraction has increased by 4.5 times since 1972, and the variation of groundwater exploitation in the country from 1972 to 2014 is shown in Figure 1 [1].

By 2016, there were groundwater over-exploitation areas in the plains of 21 provinces (autonomous regions and municipalities directly under the Central Government), with a total area of nearly 300,000 km2 and a groundwater over-exploitation of about 17 billion m3. Among them, the area of severe over-exploitation area is about 170,000 km2, which is distributed in 19 provinces (autonomous regions and municipalities) (only there are general over-exploitation areas in Heilongjiang and Guangxi). The extra-large mining areas are mainly distributed in Hebei, Shandong, Henan and other provinces. The large-scale over-exploitation areas are mainly distributed in Hebei, Xinjiang, Henan, Shandong, Shanxi, Jiangsu and other provinces [2].

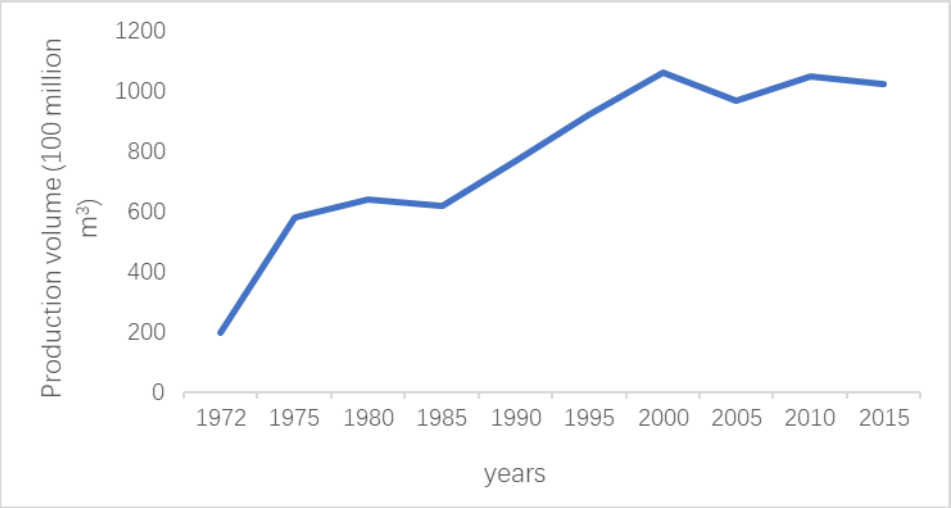

Figure 1. Changes in the amount of groundwater exploitation in the country from 1972 to 2014

1.1 Groundwater Over-exploitation in Arid and Semi-Arid Regions of Northern China

This kind of situation is more prominent in the northern region. The northern over-exploitation zone can be divided into the over-exploitation zone in the North China Plain, the over-exploitation zone in the northwest and the over-exploitation zone in the northeast. The groundwater exploitation in North China is as high as 44.2 billion m3, and the distribution area of over-exploitation area is about 178,500 km2. Hebei Province is the most serious province in the over-exploitation area in North China. The over-exploitation area in the plain area is 70,700 km2, accounting for 24% of the country. The ultra-capacity amounted to 5.965 billion m3, accounting for about 35% of the country [3].

The over-exploitation area in the northwest includes Xinjiang, Shaanxi, Gansu and other places. The over-exploitation area amounts to 68,000 km2, accounting for 16.85% of the national over-exploitation area. In the northwest region, the largest proportion of groundwater exploitation in recent years is Xinjiang, and the most growth is Xinjiang. As of 2013, the number of over-exploitation areas in Xinjiang increased by 15 from 15; the area of over-exploitation area increased from 27,100 km2 to 43,000 km2, and the over-exploitation in over-mining area increased from 1.702 billion m3 to 3.316 billion m3. The bases of groundwater exploitation in Shaanxi and Gansu provinces are relatively small, and have remained stable in recent years, with small interannual variations [1].

The over-exploitation areas in Northeast China include Heilongjiang and Jilin, among which the increase of groundwater exploitation in Heilongjiang is the most obvious, from 99.20 million m3 in 2001 to 16.76 billion m3 in 2014. The groundwater exploitation in Liaoning and Jilin Province is relatively stable and the base is small [1] . Table 1. below shows the status of over-exploitation in the plain area of the northern groundwater in the northern province.

Table 1. Over-exploitation of the plain area in the northern groundwater

provincial Administrative district		Over-exploitation area (10,000 km2)	eneral over-exploitation area (10,000 km2)	Serious over-exploitation zone (10,000 km2)	Over-exploitation area (10,000 km2)	Super mining capacity (100 million m3)
Over-exploitation area in North China Plain	Beijing	0.65	0.31	0.34	18.28	59.65
	tianjin	0.94	0.16	0.78		
	hebei	7.59	3.81	3.78		
	shanxi	1.06	0.13	0.93		

	shandong	4.22	0.84	3.38		
	henan	3.82	3.70	0.12		
Northeast over-exploitation area	liaoning	0.91	0.84	0.07	1.03	—
	jilin	0.08	0.03	0.05		
	heilongjiang	0.04	0.04	0		
Northwest over-exploitation area	shanxi	0.15	0.13	0.02	6.8	40.03
	gansu	1.63	1.62	0.01		
	xinjiang	4.30	—	4.30		
	neimenggu	0.72	0.22	0.50		

It can be seen from Table 1. that there are groundwater over-exploitation phenomena in many provinces and regions in northern China. Over-exploitation will have an impact on the ecological balance mechanism we have established, reflecting the existence of many problems in the process of groundwater exploitation in China. To exploit groundwater, to achieve sustainable economic and social development without affecting the ecological environment, and to achieve coordinated development between man and nature, this is still an urgent issue to be explored.

1.2 Groundwater Over-exploitation in the Yangtze River Delta

The Yangtze River Delta region is the region with the strongest comprehensive strength in China, but it is also a region with serious groundwater over-exploitation. It has caused serious land subsidence and other environmental problems due to over-exploitation of groundwater. At present, the Yangtze River Delta over-exploitation area is mainly distributed in Jiangsu, Anhui, Shanghai and other places. The development of groundwater in Shanghai, Hangzhou-Jiaxing-Huzhou and Suxichang has a long history, and the problem of groundwater over-exploitation is serious, leading to the problem of land subsidence, giving economic and social development and ecological environment. A bad influence has come. The deep groundwater exploitation in Shanghai caused the average accumulated land subsidence in the central urban area to be about 2 m, and the maximum settlement amount was about 3 m. The urban flood control wall experienced five times of reinforcement and the municipal infrastructure was damaged frequently, which caused serious economic losses. It also restricts the sustainable development of the city [3].

The total over-exploitation area in the Yangtze River Delta region is 15.9 million km2, accounting for 6.51% of the national over-exploitation area. Among them, the area of the general over-exploitation area is 0.32 million km2, and the area of severe over-exploitation area is 12.7 million km2. From 2001 to 2010, the Yangtze River Delta Super The annual average over-exploitation of mining area is 399.6 million m3, of which shallow groundwater over-exploitation is 0.034 billion m3, and deep groundwater over-exploitation is 0.365 billion m3 [4]. The over-exploitation situation of the Yangtze River Delta over-exploitation zone is shown in Table 2.

Table 2. Table of over-exploitation in the over-exploitation area of the Yangtze River Delta [4]

	Over mining zone type	Groundwater type		total
		Shallow groundwater	Deep confined water	
Area (km2)	General over-exploitation area	1140	2058	3198
	General over-exploitation area	8441	4283	12724
	total	9581	6341	15922
Over-exploitation (100 million m3/a)		0.034	0.362	0.396

1.3 Status of Groundwater Exploitation in Karst Areas of Southwest China

The karst areas in southwest China are mainly distributed in Yunnan, Guizhou, Guangxi, and Hunan provinces centered on Guizhou. The karst area in the southwest is rich in groundwater resources. As shown in the table, especially in Yunnan and Guizhou, the recoverable resources are 99.49% m3/a and 88.84 m3/a, respectively. Although the southwestern region is rich in karst groundwater resources, due to the skewed uplift and strong cutting of the Yunnan-Guizhou Plateau, groundwater burial is often deep, and the terrain is complex and variable, making it difficult to exploit karst water resources. The rate is low, the development degree of karst groundwater is still very low, and the development potential is large, which makes this area become one of the regions with severe water shortage in China [5].

The karst environment system is a fragile ecological environment second only to the desert edge area, and its environmental capacity is low [6]. Due to its inherent vulnerability, karst water resources are highly susceptible to human irrational activities. For example, Shuicheng Basin In the past 20 years, due to the impact of mining and industrial activities, the karst water quality in this area has undergone irreversible changes, posing a threat to the sustainable use of water resources in this area [7]. Many cities along the rivers such as Hechi, Due to the change of regional land use structure, the pollution of river water has become a water-deficient city [5].

Table 3. Table of Karst Groundwater Resources in the Four Southwest Provinces [5]

province	Total groundwater	Total karst water	Groundwater extraction
National	8501.86	2116	870
Yunnan	240.09	215.82	57.38
Guizhou	479.37	386	156.45
Guangxi	798.45	484.84	148
hunan	510.98	263.76	111.12

2. Impact of Improper Groundwater Exploitation on the Ecological Environment

The social economy is in the stage of rapid industrialization, and the impact of human activities on the ecological environment is increasing. Fragile natural ecological environment conditions, combined with strong human activities, will inevitably have a serious impact on the regional groundwater environment. Unreasonable sewage discharges will lead to serious pollution of groundwater resources and even deterioration of the water environment. With the increase in the exploitation of groundwater resources, resulting in more mining than the environmental carrying capacity, more and more groundwater over-exploitation areas have emerged, and the resulting ecological and environmental problems are not uncommon. In addition, in addition to the ecological problems caused by over-exploitation, and the unreasonable mining methods, the ecological balance system is affected during the mining process. A typical example is the abundant groundwater resources in the southwest karst area, although the groundwater exploitation is It does not exceed the environmental carrying capacity, and even has great development potential, but various ecological geological problems due to improper mining still occur from time to time.

2.1 Impact of Deep Groundwater Over-exploitation on Ecological Environment

Deep groundwater refers to confined water with a depth of 200-500. Because of its deep burial, it is weak with shallow and even surface water circulation. It participates in the deep circulation of groundwater and is mostly warm water. Deep groundwater is mostly exported in the form of well water for human use. In the early stage of deep groundwater exploitation, people did not fully understand their composition, and often developed large-scale groundwater resources on a large scale in order to satisfy the local industrial and agricultural development. Taking Hebei Province as an example, the area has sufficient sunshine, flat terrain, abundant land resources, and annual rainfall is small and

mainly concentrated in summer. Due to the limitation of hydrogeological conditions in the area, the shallow groundwater in this area has a thin sand layer, a small amount of water, and a large area of salt water. Therefore, the value of shallow groundwater development and utilization in this area is not great. Deep groundwater has become the main source of groundwater exploitation in the area. It is the main source of water for agriculture and domestic water in the region. Its water supply accounts for about 35.79% of the total water supply in the region, of which 32% is supplied by rural areas. 95% of water use is provided by deep groundwater [8]. The amount of deep groundwater exploitation in this area is affected by crops and precipitation during the period, and is affected by hydrogeology and well formation conditions in the plane distribution. With the development of industry and agriculture, the deep groundwater in the area is in over-exploitation for a long time, and mining The quantity has increased year by year, and the over-exploitation situation has become more and more serious, which has caused many ecological and environmental problems such as deep groundwater recovery and imbalance, regional water level decline funnel formation, ground subsidence, deterioration of working environment of pumping wells, and long-term drinking of high-fluorine water and human health. For the exploitation of deep groundwater, attention should be paid to adjusting its unified relationship with surface water, establishing a corresponding rational model for deep groundwater development and utilization, and vigorously promoting the development and utilization of unconventional water resources to weaken people's dependence on deep groundwater. In addition, mining should be strictly divided. Forbidden zones to control over-exploitation of deep groundwater.

2.2 Influence of Groundwater Over-exploitation on Ecological Environment in Irrigation Area

2.2.1 The Groundwater Level is Continuously Decreasing, and a Large Area of Groundwater Level is Falling.

In some places, due to long-term excessive exploitation of groundwater, the groundwater level has continued to decline, the water storage capacity has gradually decreased, and the groundwater level has fallen. Funnels, such as land subsidence, are more serious. According to the survey, there are 65 large underground funnel areas in the Yellow River Basin, and the funnel area is close to 6000km2. The groundwater level of nearly 70,000km2 in North China is lower than the sea level. In many irrigation areas in the northwest, over-exploitation occurs, such as the over-exploitation area in the Shaanxi Huihui Canal Irrigation District. With an area of nearly 900 km2, the average buried depth of groundwater increased from 4.38 m in 1985 to 12.97 m in 2000, a decrease of 8.59 m [9].

2.2.2 Natural Vegetation in the Irrigation Area is Attenuated, and the Ecological Environment is Gradually Deteriorating

Over-exploitation of groundwater in the irrigation area makes the groundwater level drop funnel in the area, which reduces the soil moisture content, causing land desertification, shallow groundwater resources to be attenuated, and it is difficult to obtain direct water for crops and plant roots planted in the area, so the groundwater level is constantly The decline, the vegetation is declining, and the situation of land desertification is getting worse. Some irrigation areas in the northwest have arid climate, rare precipitation, strong evaporation, and non-cultivated natural vegetation, mainly relying on the recharge of groundwater. Due to the over-exploitation of groundwater, the groundwater level is declining, resulting in the decline of natural vegetation [9]. The arable land is seriously deserted. As the wind migrates to cover the sandy land, the ecological environment gradually deteriorates.

2.2.3 Depletion of Groundwater Aquifers and Increased Farmland Irrigation Costs

Over-exploitation of groundwater, resulting in a drop in groundwater level has a serious impact on farmland irrigation. As the groundwater level continues to decline, the shallow aquifer is depleted, the lift of the well is increased, and the water output is reduced, which greatly increases the operating cost of the well and doubles the cost of water extraction [9]. Due to the over-exploitation of groundwater in the Weihui Canal Irrigation District of Shaanxi Province, the depth of groundwater has dropped drastically, causing a large number of machine well pumps to be hoisted, the well wall collapsed and even scrapped.

2.2.4 Salt is Concentrated in the Over-mining Area, Soil Salinization is Intensified

In some irrigation areas where groundwater over-exploitation occurs, the groundwater level falling funnel is formed, and the head pressure is formed. The surrounding groundwater is replenished to the irrigation area. The salt from the surface water for irrigation cannot be discharged, and gradually infiltrated into the deep layer. The groundwater replenished laterally around the irrigation area. The salt in the area is also concentrated in the irrigation area. After the water is lost due to the lack of drainage measures, most of the salt remains in the soil, which gradually increases the salinity of the groundwater and increases the area of soil salinization. For example, some areas in the Weihui Canal Irrigation District in Shaanxi use high-grade groundwater for irrigation, resulting in soil salinization and crop yield reduction. In Gansu Province, for example, groundwater in Gansu Minqin irrigation area is over-exploited and groundwater is formed in the irrigation area. The falling funnel, not only the groundwater salt in the irrigation area can not be excluded, the groundwater in the surrounding desert area will be replenished to the irrigation area, and a large amount of salt will enter the irrigation area, which will increase the soil salinization area in the irrigation area, making the land poor and unsuitable for cultivation, seriously affecting Agricultural production [10].

2.3 Ecological Environment Problems in Karst Groundwater Exploitation Areas

The karst area is rich in groundwater resources. Due to its complex natural and geological conditions, the ecological environment of the karst area is fragile. In the process of mining karst karst groundwater, it is necessary to consider the influence of development behavior on groundwater environment and ecological environment. In the historical experience of groundwater, there have been a series of geological disasters and ecological environmental damages that have not paid attention to protecting groundwater resources and sustainable development of ecological environment, which have led to the following karst areas, mainly in the following aspects:

2.3.1 Karst Collapse

From the relevant characteristics of karst collapse development in China, it can be found that in the karst disasters that have occurred, about 70% of human activities (especially the drainage of karst groundwater and interception of surface water) can be induced by humans. Intercepting groundwater has become the main cause of karst collapse [11]. In many karst plains and basins, due to the excessive extraction of groundwater to form a falling funnel, the groundwater level fluctuates frequently, causing karst collapse, resulting in loss of economic and life and property of ground buildings, railways, farmland, etc.; some areas are developed in deep wells, wells and other ways. The use of karst groundwater neglects the construction of wastewater treatment projects, so that the wastewater is directly discharged into the underground river, or enters the soil layer and the karst aquifer in the form of diffuse infiltration, resulting in deterioration of the water quality of the aquifer, which needs timely prevention and control [12].

2.3.2 Groundwater Quality is Contaminated

Taking the karst area in the southwestern area as an example, the karst groundwater pollution in southwest China is mainly dominated by man-made pollution, and the ecological environment caused by human activities has caused the reduction of groundwater resources. According to the measured data of Guangxi, Yunnan, Xiangxi, Guizhou and other provinces, from the 20th century Since the 1980s, groundwater resources have decreased by about 10%, while the precipitation during the same period has not changed significantly, mainly due to human economic activities, deforestation, and land reclamation [12]. The occurrence of karst groundwater pollution is usually concealed and not easy to be detected. When the polluted water source is developed and utilized by people, it will cause harm to humans and the ecological environment. The groundwater environment in the southwest karst area is deteriorating, and the pollution sources are diversified and the pollution is developed from point to ambient radiation. According to the survey, about 3,066 underground rivers in the karst area face enormous challenges of multiple pollutions in urban life, agriculture and industry, posing a certain

threat to the ecological environment [13]. The groundwater environment in the karst area is inherently fragile, and its aquifer self-purification capacity is quite limited, which determines the characteristics of groundwater pollution and difficult to purify in the area. Therefore, the exploitation of karst groundwater resources needs to follow the strict restrictions of the karst area to realize the mining area. Reasonable planning, reasonable control of mining volume, and standardized mining behavior ensure balanced development of groundwater environment and ecological geological environment.

2.4 General Ecological Problems Caused by Over-exploitation of Groundwater

2.4.1 Impact on Groundwater Environment

As an important part of water resources, groundwater is an important strategic reserve water source. In some areas, groundwater is over-exploited and has been in an over-exploited state for a long time. A large-scale groundwater drop funnel has been formed. The storage of groundwater resources continues to decline, and some aquifers are almost sparse. Dry, groundwater recharge, runoff, and drainage pathways have also been changed. As of 2014, the groundwater depth in the plain area of Beijing reached an average of 26m [14]. Compared with the end of the 20th century, the water level decreased by an average of 11m. It is estimated that the groundwater storage in the northern plains at the end of 2014 is higher than the accumulated loss in 1980. 270 billion m3 [3].

Long-term over-exploitation of groundwater will not only attenuate the groundwater volume, but also affect the groundwater quality and damage the groundwater environment. Especially for coastal cities, due to the large drop in groundwater level, the sea level is higher than the groundwater level, resulting in a water head difference, which induces seawater intrusion, seawater immersed in the coastal groundwater aquifer and gradually infiltrated into the inland [15]. The seawater intrusion in the coastal Bohai Plain is serious and the infiltration range is wide. It is estimated that about 50% of the monitoring area has a seawater intrusion distance of 10-43km; in the Yellow Sea and the East China Sea, about 76% of the monitoring area has a seawater intrusion within 5km from the shore; 80% of the southern coastal area is monitored. The seawater intrusion in the area is less than 1.5km offshore [16].

2.4.2 Impact on Geological Environment

Due to the excessive development of groundwater and the destruction of groundwater balance, the geological environment will be damaged to varying degrees, which will induce geological disasters, including land subsidence, ground fissure formation and ground collapse. The groundwater level in the groundwater over-exploitation area has dropped drastically, resulting in a significant drop in the groundwater level of the aquifer. The floating force of the water in the aquifer and the support of the pore water in the loose rock layer disappeared, increasing the compressibility of the clay soil or sandy soil. At the same time, it has changed the flow direction, flow velocity and hydraulic gradient of groundwater in the natural state, and also increased the groundwater erosive and carrying capacity, so that the soil is compressed and the ground subsidence is generated. In severe cases, it will become a geological disaster [17]. By the end of 2013, the area of the land subsidence area in the country has reached 52,000 km2, and the area with cumulative land subsidence greater than 300 mm in the plain area of Hebei Province is 44,100 km2, accounting for 60.28% of the total area of the Hebei Plain, and the maximum settlement in the area is 2.676 m [18].

2.4.3 Impact on the Surface Environment

The impact of groundwater over-exploitation on the surface environment is mainly reflected in the damage to surface water systems, land resources and natural landscapes. Impact on surface water systems; river recharge sources generally have atmospheric precipitation, groundwater or spring water. The rain and snow water supply has seasonal characteristics, which are reflected in the river's flood season and dry season. The groundwater recharge river can only show a normal flat water period, ensuring that the river does not rise and flow, which is reflected in the river. There are waters for many years to ensure that the rivers continue to flow throughout the year. The recharge of groundwater to rivers is of great significance for maintaining the activity of rivers and river basin ecosystems. Due to

the concentrated and excessive exploitation of groundwater for many years, the groundwater has been in the state of over-exploitation of groundwater for a long time, causing the groundwater level to decrease year by year, leading to the river flow dependent on groundwater recharge. In the rainy season, the river water body replenishes the groundwater, thus shortening the time of the river's flood period. In the same way, the over-exploitation of groundwater will also cause the disappearance of springs and the drying of the Hubo Marsh; the impact on land resources [20]: over-exploitation of groundwater to shallow groundwater resources in arid and semi-arid regions The amount of crops is reduced, and it is difficult to obtain water from surface crops and plant roots, which makes the surface vegetation difficult to grow, which in turn exacerbates land desertification. In addition, the drastic drop in groundwater level also changes the dynamic conditions of groundwater, so that the water field around the precipitation funnel forms a head pressure pointing to the center of the funnel. The surrounding groundwater is drained to the center of the funnel, and then the tributary effect is caused. The residual salt causes land in the soil. Salinization; damage to natural landscapes, vegetation and trees: excessive exploitation of groundwater, causing a significant drop in groundwater levels, causing wells and rivers to dry up, soil moisture loss, severely affecting the normal growth of ground vegetation and trees, destroying The beautiful natural landscape has an impact on the ecological environment.

3. Measures to Rationally Develop Groundwater Resources and Protect the Ecological Environment

3.1 Groundwater Development Management Measures

3.1.1 Strengthen Groundwater Dynamic Monitoring and Implement Groundwater Exploitation Measurement

Groundwater dynamic monitoring and mining measurement are prerequisites for the implementation of groundwater refinement management, and are the basis for the implementation of total groundwater extraction control and the most stringent management. At present, the measurement rate of groundwater exploitation is very low. It is necessary to speed up the construction of monitoring and water metering monitoring facilities, and gradually establish an integrated groundwater management platform to achieve dynamic monitoring of groundwater level, water quality, development and utilization, and over-exploitation conditions. The balance of mining balance is dynamically evaluated, regulating the supervision and management of groundwater exploitation, forming an effective supervision and management mechanism, and providing strong support for groundwater over-exploitation management and management [3].

3.1.2 Coordinate the Unified Management of Groundwater and Surface Water, and Implement Water Source Replacement

With the development of industry and agriculture, surface water in a certain space area is not enough to maintain the production and life of local residents. In order to reduce people's dependence on groundwater sources, water conservation and full exploitation of local surface water potential can be achieved, and it can be taken outside the conditions. The water transfer project can replace the groundwater in the over-exploitation area with surface water through these measures [3]. China has used this measure to alleviate the pressure of groundwater exploitation, such as the first phase of the South-to-North Water Transfer Project, and the Yellow River Project of Hebei Province. In the water area, taking the South-to-North Water Transfer Project as an example, the implementation of the South-to-North Water Transfer Project aims to alleviate the shortage of water resources and the deterioration of the ecological environment in northern China. It is an initiative to promote the overall layout of water resources optimization in the country. After the implementation of this measure, the Hebei Plain is the main Beneficiaries, as of the implementation of the first phase of the mid-line project in 2010, provided water resources for the cities of Handan, Shijiazhuang, Baoding and Xingtai, as well as water supply to Zhangzhou and Langfang, effectively alleviating the imbalance of water supply and

demand in the Hebei Plain. [9]. The completion of the external water transfer project will alleviate the current situation of over-exploitation of groundwater. By rationally arranging and coordinating external water transfer, local surface water, groundwater and other water resources, the local surface water and external water use will be increased. To enhance the mobility of water resources utilization, thereby reducing the dependence of arid and semi-arid areas on groundwater, reducing the amount of groundwater exploitation, and improving the water resources conditions in the water receiving area [3].

3.1.3 Pay Attention to the Mutual Conversion of Water Resources and Promote the Development and Utilization of Unconventional Water Resources

While rationally developing groundwater, we must also pay attention to the development of water resources such as sewage, rainwater, and seawater. Promote the promotion of crops using brackish water or brackish irrigation or mixed irrigation. Research and popularize the desalination treatment of sea water resources and the technology applied to production and life, accelerate the construction of urban water recycling facilities, and improve the recovery rate of water. The new sewage treatment project must simultaneously build water reuse facilities. Taking Zhangzhou City as an example, water supply facilities for salt water in the urban area will be established. In addition to drinking and washing, other household water such as laundry, washing vegetables, and flushing will use salt water, which can replace about 58% of fresh water resources. The use of process technology to treat used water or water sources that are not suitable for direct use, and make full use of unconventional water resources for conversion, can reduce the demand for traditional water resources [9], improve the contradiction between water supply and demand, especially in arid regions. The situation, which indirectly improves the overexploitation of groundwater and the deterioration of the ecological environment.

3.1.4 Prevent Groundwater from Being Polluted and Actively Carry out Wastewater Recycling

Groundwater is in an underground environment and is not susceptible to pollution. However, once it is contaminated, its aquifer self-repair function is limited, and it is difficult to effectively improve the polluted water quality. Therefore, it is necessary to strengthen the protection and management of groundwater sources. After the groundwater is polluted, it is necessary to ascertain the sources of pollution and their pollution pathways as soon as possible, and timely control the characteristics of the pollutants, thereby preventing the further expansion of the pollution domain and endangering the balance between human health and the ecological environment. . In addition, the classification of pollutants in industrial wastewater should be classified, so that it is easy to formulate corresponding treatment measures according to their different characteristics, so as to realize the recycling of sewage [21].

3.1.5 Improve the Groundwater Development Management System and Strictly Divide the Mining Restricted Area

The unreasonable exploitation of groundwater is mainly because people's lack of awareness of environmental protection has caused slack and blindness of behavior. The most crucial thing to solve such problems is to establish a clear groundwater development management system, and implement a clear management of responsibility and responsibility. The well is strictly controlled. In order to regulate people's development behavior. For areas with over-exploitation trend, strict groundwater level monitoring should be carried out. The monitoring system should be used to monitor the groundwater over-exploitation area for restrictive mining, and the severe over-exploitation area should be prohibited from mining [21]. Groundwater is a renewable resource that can be recharged by atmospheric precipitation and surface water, as well as other groundwater with hydraulic connections. The amount of water is recoverable. By limiting mining and prohibiting mining, groundwater levels can be reduced in over-exploited areas and severely over-exploited areas. It can be restored to improve local water resources and ecological environment and geological conditions.

3.2 Ecological Environmental Protection Repair Measures

3.2.1 Implement Vegetation Restoration and Reconstruction, and Strengthen Ecological Environment Construction

Under the influence of unreasonable exploitation of groundwater, the ecological environment has suffered a certain degree of damage. Problems such as rocky desertification, land salinization and soil erosion have emerged in an endless stream. In order to improve the ecological environment, a series of treatment measures are needed. Because vegetation has the functions of retaining water and solidifying soil, prolonging the infiltration time, and regulating the storage of groundwater [22], it is necessary to carry out vegetation reconstruction in ecologically degraded areas, especially in karst areas. In the process of natural restoration of vegetation, as the recovery time increases, the biodiversity increases and the bioaccumulation increases, so that the physical shape of the soil is continuously improved [23], and the ecological environment is gradually improved. The coordinated development of water, soil and vegetation is the key condition for ensuring ecological balance. Vigorously carry out afforestation activities, increase vegetation coverage, reduce soil erosion, extend the infiltration time of surface water, conserve water sources, and improve damaged ecosystem.

3.2.2 Improve Irrigation Efficiency in Irrigation Areas, Adjust Planting Structure, and Develop Water-saving Agriculture

High-efficiency water-saving irrigation mainly includes irrigation techniques such as sprinkler irrigation, drip irrigation, micro-sprinkler irrigation, infiltration irrigation, membrane irrigation, and high-standard low-pressure pipelines. Efficient water-saving irrigation can greatly improve water utilization, reduce crop irrigation quota, reduce operating costs, and increase labor productivity. The agronomic water saving is based on the climate, topography and economy of the planting area, through the comprehensive agricultural technology, reforming the farming system and planting system, effectively inhibiting soil evaporation and crop transpiration, and improving crop water use efficiency to achieve high water-saving production. The agricultural water-saving technical measures mainly include tillage and conservation, cover and conservation, straw returning, integration of water and fertilizer, and promotion of crop water-saving varieties. The adjustment of planting structure refers to the appropriate adjustment or reduction of the area of high-yield water crops that rely on groundwater irrigation in low-water areas to replant low-water crops or to implement fallow and rotation. For example, in the groundwater irrigation area of the North China Plain, the area of winter wheat planting can be appropriately reduced, and the two-year-old wheat-maize system can be changed into corn one-year-old system to reduce over-exploitation of groundwater [3].

3.2.3 Groundwater Exploitation in Coastal Areas Adopts Decentralized Type to Increase Groundwater Recharge and Desalinate Salt Water

Due to the excessive development of groundwater in the coastal areas, the water level is lowered, and the groundwater level is lower than the sea level. It is easy to cause seawater intrusion and pollute the groundwater quality. Groundwater can be mined through a decentralized layout to avoid a rapid decline in groundwater levels due to concentrated groundwater pumping. In addition, artificial recharge (artificial recharge, artificial infiltration) of groundwater can be implemented. This treatment can directly promote the recovery of groundwater level, effectively prevent seawater intrusion, and convert surface water resources into groundwater resources and increase groundwater resources. To improve the current situation of shortage of groundwater resources due to over-exploitation. Salt water can also be desalinated by the corresponding process technology of seawater desalination treatment. At present, the use of such technology in China is relatively mature, but the input cost is large, and it needs to be selected according to the actual situation [24].

4. Conclusion

Groundwater resources are an important part of water resources. In the development process, attention should be paid to local conditions, comprehensive consideration of local water resources, climate and

ecological environment, and reasonable development plans should be developed, whether it is arid or semi-arid areas in the north or Changsan area, southwest karst. Regions, irrigated areas, and coastal areas should properly mine groundwater under conditions that meet ecological balance. It should also focus on effective prevention and control of groundwater level decline, karst collapse, and land subsidence caused by unreasonable groundwater exploitation. Coordinate the balance of ecological environment, promote the reuse of resources, and sustainable economic and social development.

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