Assessment Method on Groundwater Recharge Effect

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Abstract: In view of the serious problem of groundwater overdraft in North China, the experimental reaches of Hutuo River, Fuyang River and Nan Juma River in Hebei Province were selected to evaluate the groundwater recharge effect. The evaluation index system of groundwater recharge effect is established by selecting indexes from the six aspects of groundwater level recovery rate, water surface area change rate, water quality improvement degree, water ecology improvement degree and public satisfaction degree. with AHP. A simple and practical index calculation method is selected to calculate and analyze the changes of indexes before and after the river reach replenishment, and to assess the effect of ecological replenishment. The results show that the groundwater recharge effect of the experimental reach can be classified into three grades by using the established groundwater recharge effect assessment technology, namely, the assessment grade of Hutuo River is "very good", that of South Juma River is "good", and that of Fuyang River is "general". The assessment results of the three pilot river sections are basically consistent with the actual water replenishment effect.

1 RESEARCH BACKGROUND

Groundwater is an important source of water supply in our country, and plays an important role in ensuring economic and social development, national drinking water safety, and maintaining a good ecological environment. Since our country began to develop and utilize groundwater resources on a large scale in the early 1970s, the amount of groundwater extraction has increased rapidly (Zhang & Fei, 2012). In China, especially in North China, the long-term large-scale exploitation of groundwater has caused serious over-exploitation of groundwater, resulting in a series of ecological and environmental problems such as groundwater table decline, river and lake surface shrinkage, land subsidence, seawater intrusion, and groundwater pollution, caused a serious threat to the protection of national water security and regional sustainable development. Our (Zhuang & Zhang, 2013) country has made it clear in 2011 that it is necessary to strengthen groundwater protection, control groundwater over-extraction, and achieve a balance of extraction and recharge (Cao & Shen, 2019). Therefore, the artificial recharge of groundwater is an important task for the development and utilization of groundwater under the new situation, and it has important guiding significance for the rational development and utilization of groundwater (Liu & Xiao, 2015).

The increase of demand for water resources due to rapid economic development has led to a continuous decrease of the total amount of water resources, which has made great progress in the research on the theory and methods of artificial groundwater replenishment (Han & Shao, 2014). Henan, Hebei, Shandong and other provinces (Li & Zheng, 2005; Huang et al, 2001), as well as Beijing, Shanghai, Tianjin, Hangzhou, Xi'an, Shenyang and other cities and some typical areas have conducted large-scale artificial groundwater replenishment experiments (Yu & Li, 2000; Sun & Miao,2001) and has achieved good theoretical and practical results. Artificial recharge of groundwater is currently the main method for regulating water resources in many countries in the world (Sun & Miao, 2001; Ziegler et al., 2001; Dillon, 2002; Sanford, 2002) and some good results have been achieved. For artificial recharge of groundwater, the main methods are recharge methods, recharge water sources, and recharge technologies, recharge water quality, recharge blockage, etc. However, it is worth noting that although domestic and foreign experts usually evaluate the effect of

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groundwater replenishment from one or more combinations of indicators such as replenishment rate, infiltration replenishment range, effective water storage rate, groundwater level, and water quality (Lemer & Issar, 1990; Bhagyawant, 2008; Elango, 2015), so far there has not been a standard of groundwater artificial replenishment evaluation method and evaluation that that widely accepted around the world. Therefore, it is necessary to explore appropriate evaluation methods and establish a simple and feasible evaluation index system for the analysis and evaluation of groundwater recharge effect. This will make the evaluation method of ecological recharge effect more scientific. Scientific evaluation methods can ensure the comprehensiveness and objectivity of the evaluation of the improvement of water resources and water environment by ecological water supplement. All of these will be conducive to the large-scale development of water resources management and evaluation, as well as the protection of groundwater resources and ecological environment recovery.

In this paper, the analytic hierarchy process is used, and its principle is the construction of evaluation index system. By analyzing the changes of typical indexes before and after water recharge, the evaluation index system and calculation method of water recharge effect are established, and the comprehensive effect of ecological water recharge is evaluated. Provide data support and scientific reference for the evaluation of groundwater recharge effect in the entire North China Plain over-exploitation area in the future.

2 OVERVIEW OF THE STUDY AREA

This paper takes the pilot section of the three recharge channels and the surrounding area within 10km of the Hutuo River, Fuyang River, and South Juma River in Hebei Province as the evaluation scope (Figure 1). The experimental rivers have been in a dry state for a long time, and the surrounding areas have been over-exploited and the water loss of rivers and lakes is serious. The pilot river sections of the three water supply channels are 477 km long, involving 26 counties (cities, districts) in 6 cities, including Shijiazhuang, Hengshui, Cangzhou, Handan, Xingtai, and Baoding. It passes through many major shallow groundwater funnel areas such as Ningbolong, Gaoliqing, and Yimu Spring.The experimental rivers have been in a dry state for a long time, and the surrounding areas have been over-exploited and the water loss of rivers and lakes is serious. Water recharge started on September 13, 2018, and as of August 31, 2019, the total water recharge volume was 1.35 billion m^3. According to the statistics of water supply sources, the middle route of the South-to-North Water Diversion Project provides water supply of 8.9 million m^3,370 million m^3 of local reservoirs and 80 million m^3 of reclaimed water. According to the statistics of the pilot river section, the Hutuo River provides 830 million m^3 of water, the Fuyang River provides 350 million m^3, and the South Juma River provides 160 million m^3,Comprehensively considering the regional impact of hydrological factors such as water recharge, precipitation, evaporation, and channel storage in the evaluation area, and the impact of water withdrawal around the river channel, In the end, the three pilot river sections infiltrated and recharged about 930 million m^3 of groundwater.

Figure 1: The location of study area.

There are 30 monitoring sections of surface water in the replenishing river section, including 10 Hutuo River, 11 Fuyang River and 9 Nan Juma River; 111 groundwater level monitoring wells (Figures 2-4), among them, 70 eyes at the groundwater level monitoring station of Hutuo River, 27 eyes at Fuyang River, and 14 eyes at Nanjuma River, all of which are automatically monitored. There are 11 water quality monitoring cross-sections (Figures 2-4), including 4 Hutuo River, 4 Fuyang River, and 3 Nanjuma River; A total of 12 survey sections were set up for the aquatic ecology field survey, including 4 Hutuo River, 4 Fuyang River, and 4 Nanjuma River; and in the later stage of water recharge, we went to three pilot river sections to conduct social impact surveys.

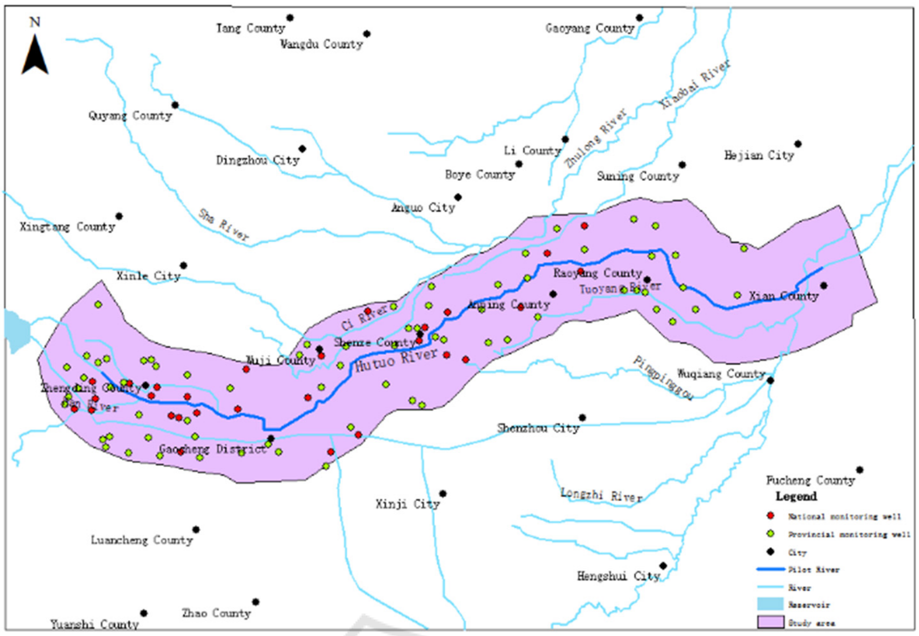

Figure 2: Layout of monitoring stations in Hutuo river.

3 EVALUATION METHOD

AHP is a multi-objective decision analysis method that based on expert experience and combines qualitative and quantitative analysis to quantify, compare and hierarchical analysis the inherent characteristics of the evaluation object. This method can not only describe the hierarchical attributes of the evaluation object, but also consider the relative importance and interrelationship of various influencing factors (Elango, 2015). Evaluation of groundwater recharge effect has comprehensive and systematic characteristics. The effect of groundwater recharge involves many aspects such as changes in the amount of groundwater recharge, changes in water quality, improvement of water ecology, and social impact. A comprehensive evaluation of the effect of groundwater recharge can be achieved by establishing an analytic hierarchy model. At the same time, the evaluation index system should follow the principles of scientific comprehensiveness, simplicity and practicality, and wide application in order to achieve an efficient scientific evaluation of the effect of groundwater recharge.

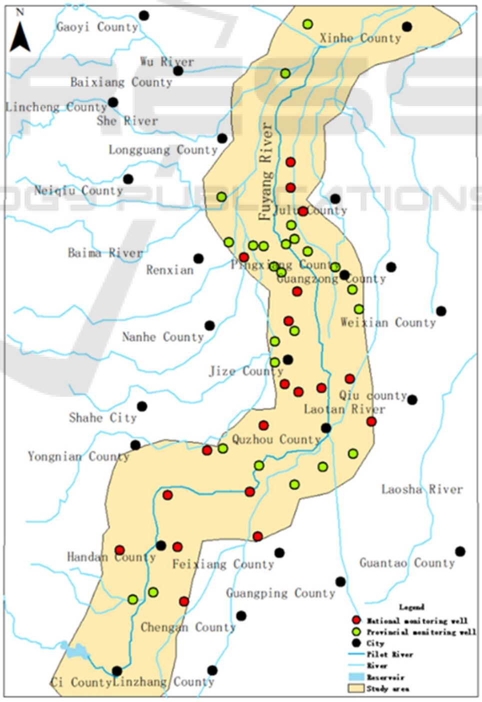

Figure 1: Layout of monitoring stations in Fuyang River.

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Figure 2: Layout of monitoring stations in Nan Juma River

3.1 Construction of Indicator System

According to the experiment experience of groundwater recharge in rivers and lakes, ecological recharge has an impact on many aspects, such as, river and lake water volume, river and lake water surface restoration, groundwater level, river and lake and groundwater quality, river and lake and surrounding water ecological environment. At the same time, in order to understand the attitudes and opinions of residents along the water recharge river and the public on the work of replenishing groundwater in rivers and lakes, it is necessary to investigate the public's satisfaction with ecological water recharge. Therefore, based on the principles of constructing the evaluation index system, six representative and easy to quantify evaluation indexes were selected as the evaluation indexes of the groundwater recharge effect: 1) Infiltration recharge rate: reflects the effective degree of infiltration and recharge of groundwater in rivers and lakes; 2)Groundwater level recovery rate: reflecting the recovery of aquifer water level after water supplement: 3)Water quality improvement degree: reflects the comprehensive improvement effect of groundwater recharge on surface water and groundwater quality, and can characterize the improvement of the water environment in the receiving area; 4) Water surface area change rate: reflects the quality of water supplement effect; 5) Water ecology improvement degree: reflects the structure of biological community and species diversity; 6) Public Satisfaction: Reflects the public's awareness, attitudes and suggestions on the work of replenishing groundwater in rivers and lakes around the water supply channel. According to the evaluation structure of groundwater recharge effect, the evaluation model is divided into two layers. From top to bottom, the first layer is the target layer, and the second layer is the index factor layer. Based on this, a hierarchical model of groundwater recharge effect evaluation is established as shown in Figure 5.

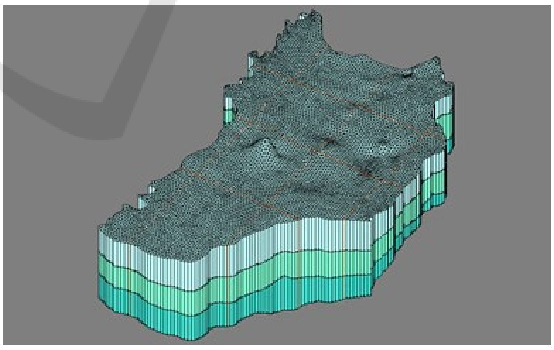

Figure 5: The evaluation model of groundwater recharge.

3.2 Index Calculation Method

The evaluation of the effect of groundwater recharge is by analyzing the changes of evaluation indicators before and after replenishing water. Evaluate the effect of ecological water recharge on improving river and lake water volume, groundwater level, water quality, and ecological environment. The data acquisition method and calculation method of the evaluation index are shown in Table 1. Because the amount of precipitation has a greater impact on groundwater infiltration recharge and groundwater level changes, so it is necessary to deduct the influence of precipitation factors for special precipitation years (such as abundant or partial abundance, dry or partial dry), and revise the assessment results. The correction mainly considers two indicators: infiltration recharge rate and groundwater level recovery rate. Refer to Table 2 for the corresponding relationship between the correction coefficient and the precipitation frequency.

Table 1: The evaluation index calculation of groundwater recharge effect.

Evaluation index	Data acquisition method	Calculation method	Method description
Infiltration recharge rate	Dynamic monitoring, data investigation	Water balance method	The calculation principle is scientific, the method is simple, and the water quantity relationship is clear. This article mainly uses this method
		Model simulation	A large amount of topographic and geological data and monitoring data are required, and the model construction and parameter adjustment are complicated, which is not suitable for short-term rolling effect evaluation
Groundwater level recovery rate	Dynamic Monitoring	Isosurface method	Analyze the area of the region where the groundwater level rises, stabilizes, and falls, and its proportion to the area of the evaluation area, through the contour (surface) map of the change of groundwater depth in the evaluation area before and after water replenishmen
		Monitoring well statistics method	When the groundwater flow field is difficult to draw, the monitoring well statistics method can be used to calculate the ratio of rising, stabilizing, and falling water level of the groundwater monitoring well.
Water surface area change rate	Remote sensing image interpretation, drone aerial survey, site survey and measurement review	Direct calculation	Calculate the change of water surface area before and after water replenishment, the higher the increase rate, the better the water replenishment effect
Water quality improvement	Dynamic Monitoring	The method of River section length	Surface water quality improvement degree calculation method
		The method of Monitoring section statistics	Surface water quality monitoring stations can be used to calculate the improvement degree of surface water quality when there are few
		Direct calculation	The percentage of groundwater monitoring wells whose water quality has improved to the total number of monitoring wells in the area represents the degree of groundwater quality improvement
			The weighted sum of the improvement of surface water and groundwater quality indicates the comprehensive improvement of water quality
Water ecology improvement	Site sampling survey	Direct calculation	Comparing changes in the types of aquatic organisms and shore cover plants before and after water replenishment to reflect the degree of improvement of water ecology.
Public satisfaction	Visit survey, issue questionnaire	Score calculation	The questionnaire adopts a hundred-point system. According to the importance of questions, assign a value to each question, and finally calculate the sum

Table 2: The correction coefficient and precipitation Frequency.

Precipitation level		high flow year	Partial high flow year	Average flow year	Low flow year	Partial low flow year
guarantee ratep / %		≤12.5	12.5 < p≤37.5	37.5 < P≤62.5	62.5 < P≤87.5	> 87.5
Correc tion factor	Water supplement coefficient	Points×0.8	Points×0.9	Points×1.0	Points×1.1	Points×1.2
	Water level recovery rate	Points×0.8	Points×0.9	Points×1.0	Points×1.1	Points×1.2

Table 3: The evaluation index judgment matrix of groundwater recharge effect.

	Infiltration rate	Groundwater level recovery rate	Water area change rate	Water quality improvement	Water ecology improvement	Public satisfaction
Infiltration rate	1	2	3	4	5	6
Groundwater level recovery rate	1/2	1	2	3	4	5
Water area change rate	1/3	1/2	1	2	3	4
Water quality improvement	1/4	1/3	1/2	1	2	3
Water ecology improvement	1/5	1/4	1/3	1/2	1	2
Public satisfaction	1/6	1/5	1/4	1/3	1/2	1

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3.3 Index Weight and Evaluation Classification

3.3.1 Index Weightand Classification of Value Division

Each index factor has a different degree of influence on the effect of groundwater recharge, and its role in the evaluation system is also different. This study uses the analytic hierarchy process combined with expert experience to construct the judgment matrix (Table 3), Calculate the maximum eigenvalue of the judgment matrix and the corresponding eigenvector by the sum-product method, and the weight value of each index factor can be obtained by normalization processing (Table 4). From a simple and practical point of view, the index values are divided into four levels on average, and each level is re-assigned from low to high. And the value of each index can refer to Table 5.

3.3.2 Classification of Evaluation Results

According to the index weight and value standard, the scores of each evaluation index can be calculated. And the sum of the scores is the total evaluation score of groundwater recharge effect. Because groundwater recharge is positive and beneficial for controlling groundwater overexploitation and improving the ecological environment, so the evaluation results are divided into four levels according to the total score: poor, fair, good and very good (significant). See Table 6 for the classification of rating results.

Table 4: Evaluation index weight of groundwater recharge effect.

Infiltration rate	0.379
Groundwater level recovery rate	0.249
Water area change rate	0.160
Water quality improvement	0.102
Water ecology improvement	0.065
Public satisfaction	0.043
CR=0.019<0.1 Meet the consistency test	

Table 5: Grading standard of evaluation index.

Index	Index value classification	Measure
Effect evaluation index	0-0.25	25
	0.25-0.5	50
	0.5-0.75	75
	0.75-1.0	100

Table 6: Classification of evaluation results.

Evaluation score	≤30	30 < p≤60	60 < p≤80	80 < P≤100
Replenishment effect	Poor	general	better	Very good (significantly)

4 EVALUATION OF GROUNDWATER RECHARGE EFFECT

4.1 Construction of Indicator System

4.1.1 Evaluation of Infiltration Recharge

According to the calculation, the total water supply of the three pilot river sections is 1.35 billion m^3, the water inflow in the interval is about 100 million m^3 (total precipitation is 9 billion m^3, and the total inflow is 1.43 billion m^3. According to the calculation of the water balance formula, the infiltration groundwater volume of the three pilot river sections is 950 million m^3 (see Table 7). And finally calculate the infiltration rate (The proportion of infiltration water in total recharge water and inflow water) is about 66%. It is calculated that the infiltration and recharge of groundwater in the Hutuo River, Fuyang River, and Nanjuma River are 656 million m^3, 183 million m^3, and 110 million m3, respectively, and the infiltration recharge rate is 80%, 44%, and 57%, respectively.

Table 7: Recharge water volume of infiltration

Unit: Ten thousand m^3

Replenishment reach	supply water quantity	precipitation	evaporation	channel storage capacity variable	River outflow	Water withdrawal along the line	infiltration capacity	Infiltration rate
Hutuo River	84077	563	2805	5987	7250		65598	80%
Fuyang river	42345	163	937	168	3719	19070	18614	44%
nan Juma River	18998	194	1060	188	5741	1230	10973	57%
Sum	142420	920	4802	6343	16710	20300	95185	66%

4.1.2 Evaluation of Groundwater Level Rise

According to the groundwater dynamic monitoring data before and after water recharge, the dynamic change process of the average groundwater level of the pilot reach is shown in Figures 2 - 4. Based on the data of multiple groundwater level monitoring wells distributed in the Hutuo River, Fuyang River, and South Juma River sections, the changes in the groundwater level before and after water supplementation were compared and analyzed. The groundwater level within 10km of the three recharge pilot rivers dropped by an average of 0.03m, and the overall situation is stable. The groundwater level of the Hutuo River section increased by 0.33m on average, the groundwater level of the Fuyang River section decreased by 0.23m, and the groundwater level of the South Juma River section decreased by 0.29m on average. But during the same period, the groundwater level in the area without water recharge (the area outside the 10km range of the pilot river section) dropped by an average of 0.96m. In a year with similar historical precipitation (2014), the groundwater level within the 10km range of the pilot river in the same period dropped by an average of 4.14m, and the comparison shows that the groundwater level has relatively increased after water recharge, and the water recharge effect is obvious. Through the Kriging interpolation calculation of the groundwater monitoring well water level data in the study area, the groundwater level recovery rates of the Hutuo River, Fuyang River, Nanjuma River and the surrounding 10km range are 36%, 17%, and 6% respectively.

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4.1.3 Evaluation of Water Surface Area Change

Interpret the water surface area of the pilot river sections at different stages by using remote sensing images of each month during the entire water supplement period before and after the water supplement. Comparative analysis shows that, compared with the severe dry-off situation in the pilot river section before water supplementation, after water supplementation, the water surface of the supplementary river section has been fully connected and the water surface area has been significantly restored. The water surface area of Hutuo River, Fuyang River, and Nanjuma River all reached the largest increase in the two months of water recharge. Among them, the water surface area of Hutuo River increased significantly, with the largest new water surface area being 21 km^2 respectively. At the end of the water recharge, the water surface area of the three river sections was 30km^2, which was 8.56km^2 more than before the water recharge, and the water surface area change rate was 39%. Among them, the Hutuo River increased by 8.91km^2, and the water surface area change rate was 78%; the Fuyang River and Nanjuma River decreased by0.09km^2 and 0.26km^2, respectively, and the water surface area change rate was -2% and -4%.

4.1.4 Evaluation of Water Quality Improvement

Analyzing the data of 11 surface water quality monitoring sections in three river sections (Table 8) shows that the water quality categories of 6 sections have improved, and the water quality categories of 3 sections are basically stable. Two deteriorating water quality sections were mainly affected by the decrease in water supply flow in the later period. The monitoring section was in a cut-off state, the water body was not flowing, and the water quality gradually deteriorated due to the influence of temperature and pollutants. Among them, the improvement rate of the surface water quality of Hutuo River and Fuyang River was 75%, and the improvement rate of surface water quality of the South Juma River was 100%. Use groundwater monitoring well monitoring data (Table 9) to analyze the changes in groundwater quality before and after water supplementation. It shows that the groundwater quality in the area where the pilot river section is located is poor, and the groundwater quality in the vicinity of the river has improved after water supplementation, and the concentration of some water quality indicators has been significantly reduced. Among them, the groundwater quality of the Nanjuma River has improved significantly, with an improvement ratio of 80%; the improvement effect of the Hutuo River and Fuyang River is not obvious, with the improvement ratios of 26% and -8% respectively. According to the improvement degree of surface water and groundwater quality of the three river sections, formula (1) is used for comprehensive evaluation and calculation.

$$\gamma = \alpha * 0.5 + \beta * 0.5 \quad (1)$$

In the formula, represents the improvement degree of surface water quality, and represents the improvement degree of groundwater quality.

It is calculated that the water quality improvement of Hutuo River, Fuyang River, and Nanjuma River are 51%, 34%, and 90% respectively.

4.1.5 Evaluation of Aquatic Ecology Improvement

A comparative analysis of the ecological environment (Table 10) between the three recharge river sections and the reference river section (the sections with no flow in the pilot area) showed that: after recharge, the aquatic species and shore vegetation of the three pilot rivers have recovered and the biodiversity is diverse. The performance has improved, and the water ecological environment has improved significantly. According to the data in Table 10, formula (2) is used to calculate the water ecological improvement degree of various organisms, and then the average value is taken to obtain the comprehensive water quality improvement degree.

$$\mu = \frac{m_1 - m_0}{m_0} \quad (2)$$

In the formula, m0 represents the number of biological species before water recharge (or reference river section), and m1 represents the number of biological species after water recharge

It is calculated that the water ecological improvement degree of Hutuo River and Fuyang River are 46% and 87%, respectively. The biodiversity of various species in the South Juma River is relatively high, and the water ecological improvement degree evaluated is 94%.

Table 8: Change of surface water quality.

Replenishment reach	Section name	Water quality in the early stage of replenishment	Water quality at the end of August 2019	Improved or stable water quality
Hutuo River	Site 1	the main water way	II	√
	Site2	the main water way	II	√
	Site3	the main water way	inferiorV	×
	Site4	IV	III	√
Fuyang river	Site5	II	II	√
	Site1	inferiorV	V	√
	Site2	the main water way/劣V	V	√
	Site3	inferiorV	inferiorV	×
Nan Juma River	Site1	II	II	√
	Site2	II	II	√
	Site3	inferiorV	V	√

Table 9: Change of groundwater quality.

Replenishment reach	Number of monitoring wells before water replenishment		Number of monitoring wells after water replenishment		Number of monitoring wells with improved water quality
	I-IIIcategory	IV-Vcategory	I-IIIcategory	IV-Vcategory	
Hutuo River	5	19	10	14	5
Fuyang rive	2	24	0	26	-2
Nan Juma River	6	5	10	1	4
Sum	13	48	20	41	7

Table 10: Water ecological improvement.

Replenishment reach			**Hutuo River**	**Fuyang river**	**Nan Juma River**
Number of aquatic organisms/ species	Benthos	Replenishment reach	14	16	29
		Reference reach	9	6	16
	Phytoplankton	Replenishment reach	34	31	36
		Reference reach	30	23	21
	Zooplankton	Replenishment reach	35	34	55
		Reference reach	27	20	36
	Fish	Replenishment reach	5	4	6
		Reference reach	3	2	2
Bank slope vegetation		Replenishment reach	13		
		Reference reach	8		

4.1.6 Evaluation of Public Satisfaction

Conduct surveys on water users, the public, government workers, etc. near the banks of the river in terms of the amount of water recharge, water level rise, water quality improvement, and ecological improvement. Regarding ecological water recharge, 90% of the people interviewed believed that the river water volume had increased significantly and expressed satisfaction with the results of ecological water recharge. Regarding the benefits of ecological water recharge, 83% of the interviewed people think that the groundwater level has rebounded, 75% of the interviewed people think that the ecological landscape has been improved; 80% of the interviewed people think that the water quality has improved after

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the water supply. According to the survey and statistical evaluation, the public satisfaction of Hutuohe questionnaire survey is 90%, that of Fuyanghe is 90%, and that of Nanjumahe is 80%.

4.2 Analysis of Evaluation Results

According to the index evaluation weights (Table 4) and the measurement method (Table 5), and considering that 2019 is a year of relatively dry precipitation, the calculation results of the infiltration recharge rate and groundwater level recovery rate are revised, and the values of each indicator are re-valued and multiplying by the weight and summing up, the final evaluation scores of the three river sections are obtained, as shown in Table 11.

Table 11: Index value and evaluation score of water replenishment effect in three river sections.

Water replenishment section	Hutuo River	Fuyang rive	Nan Juma River
Infiltration replenishment rate	100	50	75
Groundwater level recovery rate	50	25	25
Water surface area change rate	100	25	25
Water quality improvement	75	50	100
Water ecology improvement	50	100	100
Public satisfaction	100	100	100
Score	81.5	45	65

It can be seen from Table 7 that Hutuo River's evaluation score is 81.5 points, and the evaluation level is "very good"; Fuyang River's evaluation score is 45 points, and the evaluation level is "fair"; Nan Juma River's evaluation score is 65 points, and the evaluation level is "good". The evaluation scores of various indicators in the three pilot river sections are consistent with the actual water supplement effect.

The evaluation scores of groundwater level recovery rate in the three pilot river sections are all low, which is consistent with the actual situation of water level monitoring. From the actual monitoring data, the groundwater level in the Hutuo River area increased by 0.33m on average, and the groundwater level in the Fuyang River and Nanjuma River areas decreased by 0.23m and 0.29m on average. The Hutuo River's infiltration recharge rate and water surface area change rate have the highest evaluation scores, which are consistent with the actual water recharge situation. Since the amount of water recharge directly affects the amount of groundwater infiltration recharge and the change of water surface area, the more water recharge amount, the more obvious the increase in water surface, and the more groundwater infiltration recharge. Among the three river sections, the Hutuo River has the largest water supply, with 810 million m3, the Fuyang River has 350 million m3 of water, and the South Juma River has 160 million m3 of water. The improvement of water quality and water ecology is not only affected by the amount of water recharge, but also related to the natural background of the river, the quality of the water recharge and the surrounding environment along the river. On the whole, the water quality and ecological environment assessment results of the South Juma River are the best, consistent with the actual situation.

According to the comprehensive evaluation results, the Hutuo River's evaluation grade is "very good" because the two important indicators, the infiltration recharge rate and the water surface area change rate, play a decisive role. These two indicators are mainly affected by the amount of water supplemented by the river. The South Juma River is rated as "good" because the two indicators of water quality improvement and water ecology improvement are the highest. Although the water supply is the lowest in this section, but the water quality and aquatic environment of the section are good; Fuyang River The evaluation grade is "general", which is specifically manifested in the low infiltration recharge rate, groundwater recharge rate, water surface area change rate, and water quality improvement rate, mainly due to the low water recharge in this section, and affected by factors such as the increase of groundwater extraction for irrigation in the later stage of water recharge, the decrease of water recharge flow and less precipitation.

5 CONCLUSION

(1) The groundwater recharge effect in the study area is remarkable. During the recharge period, the water surface area was increased by 24km2 compared with that before the recharge. The water quality of the river was significantly improved, the ecology of the river section was restored, the species of organisms increased to a certain extent, and the vegetation on the bank increased; The infiltration and recharge of

groundwater is about 950 million m3; under the condition of a 40% reduction in precipitation and an increase in groundwater extraction along the line by 15%, the groundwater level is generally stable, with an average increase of 0.93m compared with areas not affected by water recharge, and in some areas The quality of groundwater has improved.

(2) Using the analytic hierarchy process, the groundwater recharge effect evaluation index system established by selecting indicators from the four aspects of water quantity, water quality, water ecology, and social impact, the index factors are available and dynamic, the evaluation method has operability and simplicity, and the evaluation result is more comprehensive.

(3) The evaluation grades of the water recharge effect of the Hutuo River, Nanjuma River and Fuyang River are "very good", "good", and "fair" respectively, the evaluation result is basically consistent with the actual water supplement effect, it is proved that the evaluation index system has certain applicability for groundwater recharge effect evaluation, and it can provide theoretical basis and technical support for water resources management evaluation.

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