

A Contrastive Analysis of Different Exploiting Plans Concerning Xiaohuiping Water Source Regions

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On the basis of a brief analysis of local hydrogeological conditions in Xiaohuiping Water Source Regions, three exploitation schemes are preliminarily determined: tube well, gallery and Seepage well. According to the range and the boundary conditions of the study area, the corresponding groundwater flow numerical model is established. The allowable yield of groundwater of tube well, gallery and Seepage well respectively is: 20000m³/d, 10800m³/d and 56600m³/d. By comparison of the three exploitation schemes, the Seepage well is the optimal way of water under the same technical conditions, which provides guidance significance for the rational utilization of groundwater for research in the area.

Introduction

At present, the lack of water resources and water pollution become one of the important factors of restricting the development of region's economy, especially in arid and semi-arid region of northern shaanxi. Surface water resource is relative lack, so groundwater is required to exploitation. How can exploit and use groundwater with high efficiency, low consumption is a problem that is worthy of studying.

Water shortage area restricted by local hydrogeological conditions, the conventional tube well is used to exploit groundwater, the water yield is small and can't meet the demand of water. While non-casting-well groundwater-collecting structure in the application of groundwater

exploitation, utilization and environmental restoration is increasing, and its advantages such as high yield, high efficiency, low consumption, easy management, low cost of water supply relatively also appear (Ding T et al,2013).But the choice of exploiting way should consider the various factors. In accordance with local hydrogeological conditions, the final selection of exploiting way not should be economically reasonable and technically feasible, but also meet the present and the future development of local demand. But the environmental problems should be avoided caused by excessive exploiting.

Brief Introduction of Hydrogeology

The study area is located in Jiaxian County, Shaanxi Province, China, which is in arid and semi-arid area. In the study area groundwater mainly occurs in the pore of sandy gravel layer and conglomeratic sand layer. The thickness of Quaternary aquifer is usually 14 ~ 15 m. Under the natural conditions, the rainfall infiltration recharge is the main replenishment source of groundwater. In the future, the main recharge is massive leakage recharge from the Yellow River stimulated by massive exploitation of groundwater. Overall, the Yellow River valley from floodplain trailing edge to overbank front, the groundwater occurrence conditions gradually turned for the better, especially the overbank front near Yellow River area. The pore water of

Quaternary alluvial layer can be supplied by leakage of the Yellow River, the groundwater occurrence conditions is better.

Conceptual Model of hydrogeology

The eastern boundary of the study area is the Yellow River. Under the natural condition, groundwater discharges to the Yellow River after accepting areal atmospheric precipitation infiltration recharge. Under the condition of the future exploitation, the recharge is massive leakage recharge from the Yellow River stimulated by massive exploitation of groundwater. So the Yellow River can be conceptualized as the third kind of boundary. Western boundary for interface between low hilly land and the Yellow River valley can be conceptualized as the non-flow boundary due to the low permeability bedrock. The water surface of Yellow River is broad and its long longitudinal extension, so set the upstream and downstream of the Yellow River almost into the constant head boundary; At the top of the study area is phreatic surface, which vertical water exchange such as precipitation infiltration, groundwater evaporation respectively occurs on the surface of it, so it can be conceptualized as water table boundary. Bottom surface is complete Triassic bedrock, which constitute a regional impervious boundary.

Brief Introduction of Model

According to the hydrogeological conditions in the study area, Tube well, gallery, Seepage well are used to calculation of the allowable yield of

groundwater. Corresponding model is established, the model of tube well, using pure seepage model, is solved by horizontal two-dimension finite difference method .The model of gallery and Seepage well, using the "seepage – pipe" flow coupling model (Wang and Zhang, 2007), is solved by

three-dimension finite difference method(Chen C et al., 2004). In the study area, the results of model discretization are shown in table 1.

Table 1. Result of discretization

Exploitation scheme	Discretization		Horizontal interval(m)	Number of active cell	Layer		Total number of active cell	Horizontal area(km ²)
	Column	Row			Quart-erna ry	Bed-rock		
Tube well	130	420	10	22926	1		22926	
Gallery	260	840	5	91712	6	4	917120	2.293
Seepage well	260	840	5	91712	4	8	1100544	

According to the characters of aquifer distribution, Xiaohuiping Water Source Region is divided into four parameter regions. The permeability coefficient from north to south respectively is 7.98 m/d, 22.54 m/d, 18.95 m/d, 15.00 m/d. The specific yield is 0.20. Due to small area of the model, and the amount of rainfall infiltration and evaporation is small than exploitation under the condition of stimulation river leakage recharge, so the model can be established ignoring sources and sinks except for the designed exploitation quantity of groundwater. For the simulation calculation only considers the drawdown of space and time

change under different exploiting schemes, the Yellow River stage is thought as initial head.

The Allowable Yield Calculation of Different Exploitation Ways

Tube Well

Wells are located in the appropriate location of Xiaohuiping model district. Each tube well's diameter is 0.356m. Design three kinds of the number of tube well, each solution tube well number respectively is 19(well distance 80 m), 15(well distance 100

m), 13(well distance 120 m). According to pumping test data, the three kinds of exploitation quantity are designed, respectively for 1600(1800,2000),2000(2200,2400), 2400 (2600,2800) m³/d. Each kind of exploitation quantity has three decided by the good or bad permeability of the location of the tube well. So a total of 9 kinds of exploiting scheme are designed. The two-dimensional grid finite difference method is used for numerical simulation to calculate the allowable yield. The results as shown in figure 1.

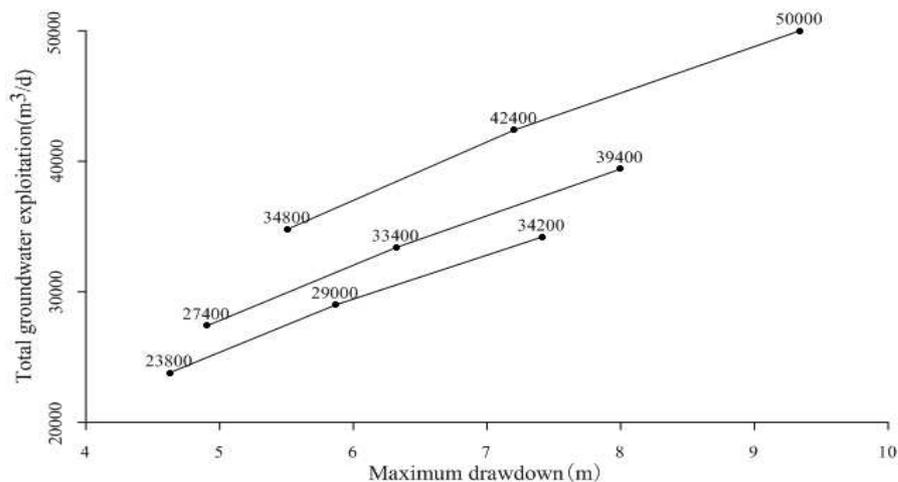


Fig 1. The relationship between maximum drawdown and total groundwater exploitation

The figure1 shows that the drawdown of tube wells increase with the growth of total exploitation. In order to have relatively large exploitation under the condition of

relatively small drawdown, the second scheme is recommended for the exploitation of groundwater in this area, exploiting well number is 19, well distance is 80 m, single well

exploitation is 2000 (2200,2400) m³ / d, total exploitation of normal season is 42400 m³ / d.

Given in June and July, the Yellow River water stage fall, water edge

retreat, this will certainly influence that the exploitation of single well will decrease compared with that in normal season along the river. So adjusting the single-well exploitation quantity, and closing the individual single well which has dried up. The model for 60 days unsteady numerical simulation is rerun. The initial flow field is the steady flow field. Water boundary is identified with water edge of the Yellow River in the dry season. The Yellow River water stage decreases by 1 m. The water yield of recommended exploitation scheme of tube well is 20700m³/d in the dry season.

Gallery

The allowable exploitation mainly depends on the stimulated river leakage recharge, so gallery layout is along the Yellow River water boundary of dry season in the study area, length of 1441 m. Gallery cross section is width 2 m, high 2 m. A well is set at the end of the gallery downstream. Shaft lining don't permeate water. Designing buried

depth of gallery respectively is, 2 m, 3 m, 4 m, 5 m, 6 m, corresponding shaft drawdown under the condition of different buried depth of gallery respectively is from 1 to 2 m, 1 to 3 m, 1 to 4 m, 1 to 5 m, 1-6 m. In the study area designing gallery different buried depth and well drawdown a total kind of 20 the corresponding computing scheme. "Seepage – pipe" flow coupling model(Chen and Hu,2008) is adopted to calculate.

Calculation results show that when the shaft has the same drawdown, the gallery buried depth has little impact on water yield. With the increase of shaft drawdown, gallery water yield increased significantly, and with the gallery buried depth increases its construction difficulties and construction cost will be increased significantly. For that reason, the scheme of buried depth of 5 meters, drawdown of 5 meters is recommended to exploitation of the groundwater of the Yellow River valley areas, suggested that the proposed yield is 33000 m³ / d. Calculation results of dry season show

that under the condition of the Yellow River water stage fall, water edge retreat, water yield of gallery has a significant reduction. When the shaft water stage is constant, the water yield of gallery is reduced to 10843.60 m³/d, which reduce 67.16% than that in the normal season, the proposed yield water of gallery is 10800 m³/d in the dry season.

Seepage Well

According to aquifer structure, parameters of this area, two kinds of solutions are proposed to exploit ground water. Scheme one have 5 Seepage wells(two vertical wells are 750 m apart); Scheme two have 7Seepage wells (two vertical wells are 500 m apart).To accurately depict the Seepage well complex structures, used 5 m x 5 m grid to fine discretize of computational domain, detailed in table 1.On the basis of the discretization results, the Seepage well "seepage - pipe " coupling model established to solve. The calculation results are shown in table 2.

Table 2. Results of simulation Seepage well for the water yield

scheme	calculation period	well number	single well		multiple wells		proportion of decrease(%)
			total yield (m ³ /d)	proposed yield (m ³ /d)	total yield (m ³ /d)	proposed yield (m ³ /d)	
scheme one	normal season	5	52932.64	52900	52918.45	52900	0.03
	dry season		41443.22	41400	41235.41	41200	0.5
scheme two	normal season	7	75624.9	75600	75435.27	75400	0.25
	dry season		59341.49	59300	56673.34	56600	4.5

Respectively comparing calculation result of single well and multi well in scheme one, the mutual interference of two Seepage wells is small, Seepage wells' layout do not have a significant impact, the total water yield of multi well reduce by 14.16 m³ / d than that of single well in the normal season, decreasing by only 0.03%, while in the dry season the total water yield of multi well reduce by 207.81 m³ / d than that of single well, decreasing by 0.50%.

Contrasting calculation result of single well and multi well in 7 Seepage wells scheme shows that while adding a Seepage well makes

the distance between the adjacent two Seepage wells is reduced, but the mutual interference between Seepage wells have not significantly increased. The calculation results show that the total water yield of multi well of Xiaohuiping model reduce by 189.6 m³ / d than that of single well in the normal season, decreasing by only 0.25%,while in the dry season the total water yield of multi well reduce by 2668.15 m³ / d than that of single well, decreasing by 4.50%.

By contrasting of the calculation result for water yield of Seepage well of normal season and dry season, it shows that although water edge retreat

during the dry season, the seepage holes are still located below the Yellow River accompanying with water stage fall .It will result in diminishing the hydraulic gradient when the groundwater receive leakage recharge of the Yellow River, thus make the Seepage well water yield decreased significantly. Considering Seepage well construction costs, the number of water point, single well water yield and total water yield, 7 Seepage wells are recommended to exploit groundwater resources in the study area, suggesting that the proposed yield is 56600 m³ / d.

Scheme Selection

In conclusion, the allowable yield of tube well recommended in normal season is 42400 m³ / d, while in dry season is 20000 m³ / d. According to the evaluation result, the allowable yield of gallery in normal season is 33018.71 m³ / d, in dry season is 10843.60 m³ / d, which is decreased by 67.06% in dry season than that in normal season. Seepage well recommend solution suggest that the allowable yield is 56600 m³ / d. Seepage wells have many advantages such as large water yield, less water intake points and easy management. With the water edge retreat, Seepage well water yield decrease by 4.50%.

By comparing the above three methods for exploiting water, non-casting-well groundwater-collecting structure such as gallery, Seepage well is better than traditional tube well from water intake effect; Contrasting gallery and Seepage well two similar ways of exploiting water from the reduction of water yield when water edge retreat into consideration, under the condition of stimulating the scope of leakage recharge of the Yellow River. Seepage well is larger than gallery, therefore Seepage wells for water intake is better than gallery; Comparing two types of exploiting way Seepage well

and gallery, and under the condition of quite well distance range, two types of water yield were similar, but due to the seepage hole below the Yellow River, the effect of stimulating leakage recharge of the Yellow River is better. Under the condition of water edge retreat during the dry season, this advantage is more obvious. Therefore Seepage well is recommended to exploitation of groundwater in the area.

Conclusion

Three kind of exploitation way are designed for Xiaohuiping water source, and the water yield of various exploiting way is calculated respectively. Through the analysis of three kinds of water intake effect, Seepage well is determined to exploit groundwater in the Xiaohuiping Yellow River valley area. There are 7 seepage wells in total, the allowable yield is 56600 m³ / d.

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