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Real-time Dynamic Simulation and Prediction of Groundwater in Typical Arid Area Based on SPASS Improvement

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Abstract. The establishment of traditional groundwater numerical simulation model, parameter identification and inspection process, especially the water level fitting and the actual observation of the value obtained compared to a large error. Based on the SPASS software, a large number of statistical analysis of the numerical simulation results show that the complexity of the terrain in the study area, the distribution of lithology and the influence of the parameters on the groundwater level in the study area have great influence on the groundwater level. Through the multi-factor analysis and adjustment, the simulated groundwater flow and the actual observation are similar. Then, the final result is taken as the standard value, and the groundwater in the study area is simulated and predicted in real time. The simulation results provide technical support for the further development and utilization of the local water resources.

1. Introduction

The establishment of traditional groundwater numerical simulation model, parameter identification and inspection process, especially the water level fitting and the actual observation of the value obtained compared to a large error[1,2]. Based on the SPASS software, a large number of statistical analysis of the numerical simulation results show that the complexity of the terrain in the study area, the distribution of lithology and the influence of the parameters on the groundwater level in the study area have great influence on the groundwater level[3,4]. Through the multi-factor analysis and adjustment, the simulated groundwater flow and the actual observation are similar. Then, the final result is taken as the standard value, and the groundwater in the study area is simulated and predicted in real time. The simulation results provide technical support for the further development and utilization of the local water resources.

2. Overview of the study area

The new area is located in the northeast of Zhungeer flag and its surrounding areas, the study area for the entire Dagou watershed, the southern boundary for the valley basin, the northern boundary for the Kubu its desert, the eastern boundary for the Yellow River, Tree Bay area. East and West 16 km long, 12 km wide from north to south, an area of about 192km².

The main settlements, roads and surface water in the study area are shown in Figure 1.
3. Groundwater dynamic simulation

3.1. Hydrogeological conditions

(1) Vertical boundary

Based on the analysis of the previous hydrogeological data in the former study area, the shallow aquifer, which is closely connected with the upper hydraulic connection in the simulation area, is generalized into a model layer. The clay layer between the shallow and deep aquifers is generalized to the model Floor. According to the data show that the aquifer lithology to the main silt, containing gravel, so the aquifer is generalized as heterogeneous isotropic media.

The upper boundary of the simulation area is the submerged surface, which mainly accepts the vertical water exchange of atmospheric precipitation infiltration recharge and irrigation return supply. In summary, when the groundwater simulation is carried out, the area where the project is located is generalized into one aquifer and one aquifer.

(2) Around the border

Because the simulation range is not a complete hydrogeological unit, the diving water group in the area has a close hydraulic connection with the outer aquifer in the horizontal direction, so the model is treated as a flow boundary around it. According to the permeability coefficient of the aquifer, the hydraulic slope at the cross section, and the cross-sectional area, the Darcy's law is obtained [5,6].

(3) Generalization of hydraulic characteristics

The evaluation of the Quaternary loose rock in the evaluation area of the aquifers and aquifers, with a unified runoff field, groundwater movement to the level of the main way. The subsurface flow varies with the precipitation at different times and is a function of time and can therefore be generalized as an unsteady flow.

In summary, the conceptual model of the groundwater system in the simulated area can be generalized into a nonhomogeneous isotropic unsteady flow groundwater system.

3.2 Mathematical model of groundwater flow

According to the hydrogeological conditions of the study area and the relevant geological data and geological survey report, related literature, groundwater recharge, runoff and excretion conditions in the past area [7], the groundwater flow model of the study area can be expressed as follows:
\[
\begin{align*}
\frac{\partial}{\partial t} \left( K \left[ H - Z(x,y) \right] \right) + \frac{\partial}{\partial x} \left( K \left[ H - Z(x,y) \right] \frac{\partial H}{\partial x} \right) + \frac{\partial}{\partial y} \left( K \left[ H - Z(x,y) \right] \frac{\partial H}{\partial y} \right) - \varepsilon &= \frac{\partial H}{\partial t} \quad (x,y) \in \Omega, \quad t > 0; \\
\frac{\partial H}{\partial n} &= -q(x,y) \quad (x,y) \in \Gamma_2, \quad t > 0
\end{align*}
\]

Among them:
- \( \Omega \) - Seepage area;
- \( H \) - Groundwater level (m);
- \( K \) - The permeability coefficient (m/d) of the aquifer in the horizontal direction;
- \( \varepsilon \) - Source sink items of the aquifer (m/d);
- \( H_0 \) - Initial water head (m);
- \( \Gamma_2 \) - Seepage region of the second class boundary;
- \( n \) - The normal direction of the boundary plane;
- \( \frac{\partial}{\partial n} \) - Derivative (dimensionless) of the direction \( n \) in the normal direction;
- \( q \) - On the boundary of a single width flow (m\(^2\)/d), into the positive and outflow is negative;
- \( Z(x,y) \) - Aquifer floor elevation.

3.3 Establishment of numerical model of groundwater flow

The simulation area is the 19th projection zone (6° band) of the Gaussian projection. According to the purpose of the groundwater numerical simulation, the rectangular model is adopted for the whole model area. The results of the numerical model are as follows:

In the plane, the model is divided into 120 rows and 160 columns with a length of 0.1km×0.1km and a total of 19200 rectangular grids. The top elevation of the model is the surface elevation and the bottom to the dive floor. The effective calculation unit is 19200, and the calculation node is located in the center of the cell\[8,9\].

4. SPASS Identification and Verification of Numerical Model Data

4.1 The initial flow field after simulation

According to the information available, this simulation period is selected from December 2016 to July 2017 in July, which in December 2016 as the initial flow field model, in May 2017 as a model to identify the flow field, the month as a time Step length.

The initial water level is based on the water level in December 2016, the extrapolation of the remaining areas, and then according to the interpolation method and extrapolation method to obtain the initial flow of aquifer aquifer as shown in Figure 2.
It is found that the simulated groundwater flow field can not accurately reflect the initial flow field of groundwater when the groundwater numerical simulation is carried out, and the initial flow field of the simulation is very different from the actual observation value. It is found that if the Some of the hydrogeological parameters of the study area are partitioned [10,11], and some of the groundwater sinks are considered. These factors are incorporated into the evaluation of groundwater level and groundwater resources, which will allow the numerical simulation software to simulate more close to the actual observations. The survey found that the groundwater level of the study area and the simulated area of the parameter area, stratigraphic lithology, geological and geomorphological complexity of the table have the following relationship (see Table 1).

| Parameter partition | Simple | Medium | Complex | More complex |
|---------------------|--------|--------|---------|--------------|
| Area I              | 970    | 972    | 976     | 974          |
| Area II             | 990    | 989    | 990     | 1000         |
| Area III            | 1010   | 1018   | 1015    | 1019         |
| Area V              | 970    | 980    | 976     | 969          |

Through the statistical analysis of SPASS software, it is found that the groundwater level in the study area is related to the parameter zoning, stratigraphic lithology and geomorphological complexity of the simulation area. If these factors are included in the simulation of groundwater numerical simulation, then will make the simulated flow field closer to the actual value (see Table 2).

### 4.2 Identification of the model

Through the repeated simulation and SPASS statistical software analysis, the new factors are taken into account in the process of simulating the groundwater flow field. It is found that the hydrogeological parameters of the groundwater system are better characterized by the hydrogeological characteristics of the groundwater system [12,13]. Identify the programmed planar flow field and the parameter values in Table 2.

| Parameter | I | II | III | IV |
|-----------|---|----|-----|----|
| Hydraulic conductivity (m/d) | 0.004 | 0.01 | 0.60 | 0.067 |
| Specific yield | $2 \times 10^{-4}$ | $2.0 \times 10^{-3}$ | $1.2 \times 10^{-2}$ | $1.6 \times 10^{-4}$ |

### 4.3 Analysis of Water Level Fitting Result

The hydraulic geologic parameters of the model are adjusted by the trial and error method, which makes the calculation of the water level and the observation water level fit well, satisfying certain precision requirements [14].

According to the above principles, the groundwater system in the study area was modeled. After the trial and error method, and finally get the ideal model recognition results, the fitting results are shown in Figure 3.
It can be concluded that the groundwater model established in this study basically conforms to the actual hydrogeological conditions of the evaluation area and basically reflects the flow field characteristics of the groundwater system. Therefore, based on the SPASS data processing software, the groundwater dynamics in the study area is predicted and evaluated is reasonably credible.

5. Conclusion

The results show that the results of groundwater numerical simulation are closer to the actual observations, and some factors that are closely related to the groundwater level must be taken into account. Based on the SPASS statistical software analysis, it is found that the groundwater level of the study area and the parameters of the simulation area, stratigraphic lithology, geological and geomorphological complexity of the degree of a certain degree of correlation, if these factors into the groundwater numerical simulation of the situation, then the simulation of the flow field will be closer to the actual value. The simulation results show that the parameter partition and other related factors are feasible in the evaluation system of groundwater numerical simulation. Qualitative to semi-quantitative analysis of groundwater flow field will form a more perfect evaluation system of groundwater dynamics. Based on the software, the evaluation scheme is more comprehensive and reasonable in the groundwater resources evaluation system, which can provide a sufficient basis for the location and exploitation of the groundwater source sites of the local residents and some enterprises, and further make the resources and the environment reach a balanced development.

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