

Summary of Simulation Research on the Influence of Infiltration Well Concentrated Infiltration on Groundwater

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Abstract

During the construction of sponge cities, the impact of concentrated rainwater infiltration on groundwater has attracted much attention because of its importance. Rainwater gardens and rainwater seepage wells are two typical rainwater facilities. The impact of concentrated infiltration of these two typical rainwater facilities on groundwater level and water quality is currently the focus of international research. This article focuses on the impact of concentrated infiltration on groundwater through on-site monitoring analysis and simulation prediction of rainwater gardens and rainwater seepage wells.

Keywords

Simulation Research; Infiltration Well; Concentrated Infiltration.

1. Introduction

At present, groundwater models have been widely used in the prediction, evaluation and management of groundwater resources. Groundwater simulation software can simulate groundwater flow, groundwater pollutant transport and groundwater level, so as to simulate the impact and scope of concentrated infiltration of rainwater garden on groundwater level and water quality. Visual MODFLOW is a comprehensive software developed by Waterloo Hydrogeology Company of Canada based on MODFLOW model and integrated with existing MODPATH, MT3D, RT3D and Win PEST models, which can facilitate and effectively carry out water flow simulation, solute transport simulation and Reaction transport simulation [1]. Visual MODFLOW uses finite difference method, which has powerful visualization function, simple solution method, wide application range, excellent numerical simulation ability and simple three-dimensional modeling.

It mainly simulates the changes of groundwater level under different fillers, that is, under different parameters, and the depth of water level and water quality migration under different influent concentrations.

2. Simulation Prediction

The commonly used analysis methods for groundwater numerical simulation are finite difference method and finite element method. The finite difference method is based on the basic differential equation of groundwater flow and its definite solution conditions. On the basis of

the seepage area dissection, the difference quotient is used instead of the derivative. The solution of the differential equation of groundwater flow is transformed into a difference equation. The finite element method divides the computational domain into a finite number of non-overlapping units. In each unit, the definite solution problem describing the groundwater flow is transformed into a differential equation for discrete solution by means of subdivision and interpolation. Compared with the finite element method, the aquifer boundary processed by the finite difference method is more regular, and the calculation and solution method are simpler. For solving the groundwater flow problem, the finite difference method has higher accuracy. Visual MODFLOW is a computer program developed by the United States Geological Survey (USGS). It is a popular internationally popular 3D visualization standard software for groundwater resources evaluation and prediction. It has powerful visualization functions, simple solution methods, wide range of applications, and excellent numerical simulation capabilities. And three-dimensional modeling is simple. This software was developed by the Hydrogeology Company of Waterloo Company in Canada, and is a relatively mature software for numerical simulation and calculation of groundwater flow using the finite difference method [2]. It is composed of MODFLOW, MT3DMS, PEST, MODPATH, UCODE and other modules, with functions such as groundwater flow simulation, tracer tracking simulation, and solute transport simulation.

3. Generalization of Hydrogeological Conditions

The impact of concentrated infiltration of infiltration wells on the groundwater level and water quality is relatively small. In order to determine the replenishment and drainage conditions in the study area, two methods are used to simulate the groundwater level and water quality. According to the geological survey data, the infiltration well is general for diving, it receives atmospheric precipitation replenishment and Wei River replenishment, and the main drainage method is artificial well water extraction. The first method is the numerical simulation of groundwater in a large area. It is proposed to adopt a fixed head boundary. The determination of the fixed head boundary is based on the geological survey data. That is, in the case of the original bare ground, the replenishment of the simulation area includes rainfall and water movement in the surrounding area. As well as the supply of the Wei River, consumption includes evaporation and supply to surrounding areas, as well as water well mining [3]. The second method is the numerical simulation of groundwater in a small area. This method is difficult to determine the flow of groundwater. In a small area, the water flows from a high water level to a low water level. In the short term, it spreads from the seepage well to the surroundings in a "triangular" type [4]. It is proposed to establish a numerical model by means of an unsteady flow, and the water head changes with the inflow and seasonal changes of the Wei River.

4. Mathematical Model Establishment

4.1. Mathematical Model of Unsteady Groundwater Flow

As a widely used groundwater flow model, MODFLOW uses a three-dimensional finite difference calculation method. The basic equation is as follows:

The basic equation of three-dimensional unsteady flow of groundwater with constant density:

$$\frac{\partial}{\partial x} \left(\kappa_x \frac{\partial h}{\partial x} \right) + \frac{\partial}{\partial y} \left(\kappa_y \frac{\partial h}{\partial y} \right) + \frac{\partial}{\partial z} \left(\kappa_z \frac{\partial h}{\partial z} \right) - q = \mu_s \frac{\partial H}{\partial t}$$

Where k is the permeability coefficient of the groundwater medium in the phreatic layer along the three dimensions of x, y, z [LT⁻¹];

q —source and sink of groundwater;

Establish the definite solution condition:

$$H|_{B1} = H(x, y, t)$$

$$H \frac{\partial H}{\partial n} \Big|_{B2} = q(x, y, t)$$

4.2. Mathematical Model of Steady Flow of Groundwater Flow

As a widely used groundwater flow model, MODFLOW uses a three-dimensional finite difference calculation method. The basic equation is as follows:

The basic equation of three-dimensional steady flow of constant density groundwater:

$$\frac{\partial}{\partial x} \left(\kappa_x \frac{\partial h}{\partial x} \right) + \frac{\partial}{\partial y} \left(\kappa_y \frac{\partial h}{\partial y} \right) + \frac{\partial}{\partial z} \left(\kappa_z \frac{\partial h}{\partial z} \right) - q = 0$$

Where k is the permeability coefficient of the groundwater medium in the phreatic layer along the three dimensions of x, y, z [LT-1];

q —source and sink of groundwater;

Establish the definite solution condition: $H|_{B1} = H(x, y, t)$

$$H \frac{\partial H}{\partial n} \Big|_{B2} = q(x, y, t)$$

4.3. Mathematical Model of Groundwater Quality

The MT3DMS model is a computer model used to simulate the convection, dispersion, and chemical reaction of various pollutants in a three-dimensional groundwater flow system. The model is used to connect the finite difference flow model. This connection is based on changes in the concentration field and does not affect the flow field. The mathematical model of water quality under the two flow modes will not change. The model equation is as follows:

$$\frac{\partial c}{\partial t} = \frac{\partial}{\partial x_i} \left(D_{ij} \frac{\partial c}{\partial x_j} \right) - \frac{\partial}{\partial x_i} (V C_i) + \frac{q_s}{Q} C_s + \sum R_k$$

In the formula,

C —concentration of pollutants in groundwater [CL-1];

t —time [T];

D_{ij} —hydraulic diffusion coefficient;

V_i —groundwater seepage fluidity [LT-1];

q_i —represents the unit flow of source and sink [T-1];

C_s —concentration of source and sink [CL-1];

Q —The porosity of aquifer [%];

R_k —Chemical reaction items.

5. Study Area Model Establishment

After the mathematical model of groundwater flow and water quality in the study area is established, the mathematical discretization of the nodes of the geological body in the simulation area should be carried out to transform the complex seepage problems of groundwater into simple and regular seepage problems in the section cells. The numerical calculation of this simulation adopts the finite difference method [5].

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