Groundwater flow modeling using visual modflow, a case study from southwest Iran

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1. Abstract

The modeling as an efficient method and with low cost will make it possible to be familiar with complex nature of groundwater systems. Thus, it can play a key role in designing and performing development projects and appropriate management of water and soil resources. Ahvaz, the center of Khuzestan province, with more than one million populations, is located in southwest Iran. It has big industrial and agricultural establishments. During recent years, water resources of the region have been encountered with problems due to overgrowth of industrial establishments, overpopulation and unwanted drought. To evaluate the existing situation and planning for optimal usage of water resources, an aquifer in northeast Ahvaz was simulated by visual moflow. The results made indicate that with continuation of this condition, the water balance equation of the aquifer, in near future will be more negative, and this will lead to tension in the region. Thus, this requires us to adopt appropriate policies including the change of pattern of water usage and making artificial recharge in order to normalize the situation.

2. Introduction

The case study is focused on 40 km far from NE Ahvaz and SW of Iran (figure 1). This region covers an area of about 200 km², situated between latitudes 31º, 20´ to 31º, 48´ N and longitudes 48º, 47´ to 49º, 15´ E. From geological point of view, it has a simple structure composed of anticlines and synclines that is the obvious feature of the southern parts of the Zagros. Siliciclastic rocks and evaporates of Fars group (Miocene) and Quaternary alluviums are the main components in the region (Motiei, 1993).

It has hot and dry climate with annual precipitation and evaporation about 250 mm and 1900 mm respectively (Rouhipour, 2006). Karoon, the largest river in Iran, flows through this province. More than one-third of Iran's total surface water of 94 billion m³ is flowing into the Khuzestan, but ironically most of its inhabitants in central and southern portions face with the problem of water supply, especially during the summer months (Afkhami et al., 2007). This research aims at groundwater flow modeling of an aquifer in NW Ahvaz by visual modflow. This will finally help us to predict hydrogeological parameters and then manage the related affairs optimally.

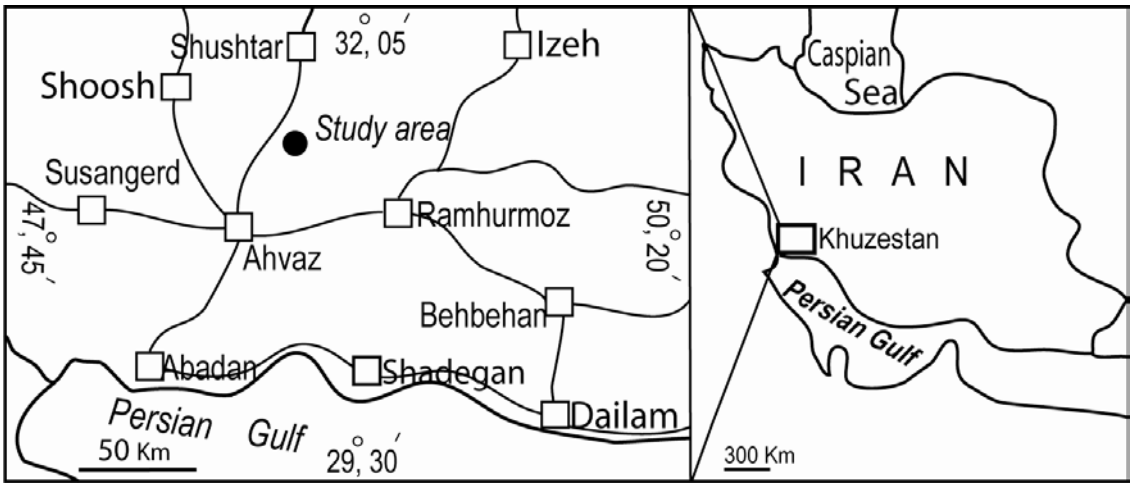

Figure 1 The location map of study area

3. Methodology

A model may be defined as a simplified version of a real-world system (here, a groundwater system) that approximately simulates system (Bear et al., 1992). Visual modflow (modular groundwater flow) which is a 3-dimensional finite difference groundwater model with a block centered net model (Harbaugh and Mc Donald, 1996) was used to simulate the hydrogeologic regime in the region. Its two key components are conceptual

model and a mathematical model. The conceptual model is an idealized representation (i.e. a picture) of our hydrogeological understanding of the key flow processes of the system. A mathematical model is a set of equations, which, subject to certain assumptions, quantifies the physical processes active in the aquifer system being modeled (Middlemis et al., 2001).

4. Discussion and results

Water resources in Khuzestan province can not satisfy all requirements in the region, as the result of such problems as hot and dry climate, the overgrowth of industrial establishments (e.g. oil, power plant, petrochemical and Gane-sugar industries). Such problems have been leading to contamination of surface water and sever decrease of groundwater table (Jafarzadeh et al., 2004).

This study aiming at exact evaluation of hydrogeological situation of aquifer in NE Ahvaz, at the beginning with the study of 210 well logs, 16 groundwater monitoring wells, 110 geophysical sondages and topographic map, we got access to database including water table and bedrock level. Then, the aquifer domain, its general form and boundary conditions were determined by constructing a conceptual (hydrostratigraphic) model. This model domain was created as a 25km by 30km grid in the X and Y (corresponding with NE-SW and NW-SE, respectively) directions, respectively, with a general uniform grid spacing of 500m between grid nods (figure 2).

Considering the fact that Karoon River is located in the western part of the region, and existing database indicating that river water surface is lower than the water table of aquifer, we created some unreal discharge wells in the boundary cells of that part of the model domain. In other parts of the plain, boundary condition was assumed as the second type (Newman type) that is, after initial calculating of inlets and outlets of the system, in the model domain discharge and recharge wells were made. Regarding efficient factors on the aquifer such as rainfall, evaporation, discharge by wells and its return coefficient (28˙/.) the parameters of water balance were defined and the model came ready to run.

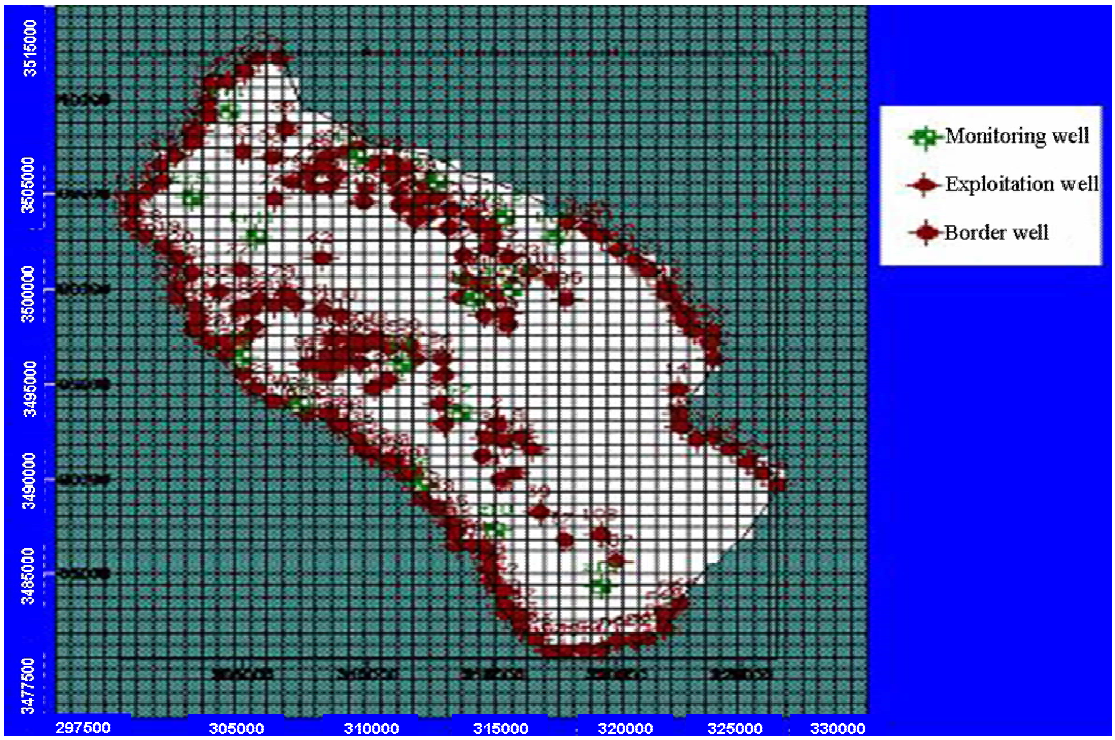

Figure 2 Model domain

The model was run at steady state, and then calibrated to average hydraulic heads recorded for up to four quarters annually from April 2003 to October 2005 (about 900 days). Model calibration consisted of modifying the hydraulic conductivity and recharge parameters to minimize the residual mean squared (RMS) error between predicted and observed heads. Following calibration, the model exhibited an RMS of approximately 0.2, as presented in the calibration plot presented as figure 3. The final stage, with the selection of time limit of 6 months, the model was validated.

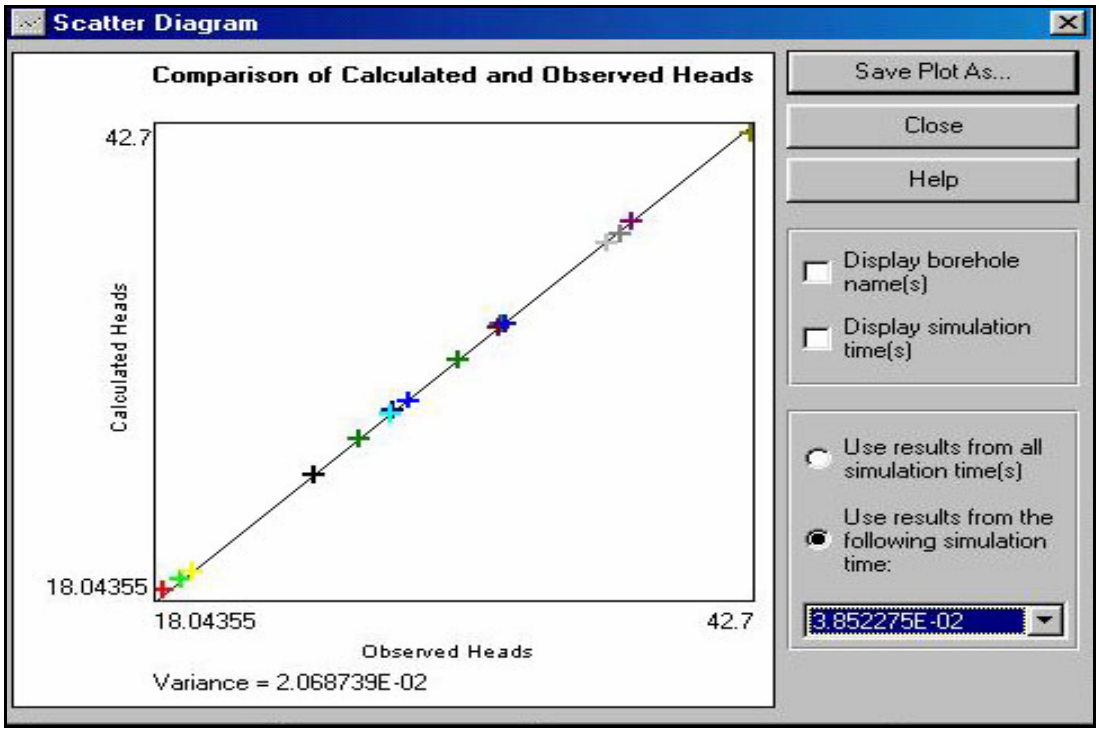

Figure 3 Calibration scatter plot

After the verification of the amounts of the model parameters, hydraulic coefficient of the aquifer that is, specific yield to the degree of 0.09-0.36 and hydraulic conductivity to the degree 2-22 m/day were gained. Rainfall penetration was estimated about 30˙/.. The results made for running the model for 2007 predict the decrease aquifer storage to the degree of 5.23 million m³. To remove such unfavorable conditions of aquifer, following suggestion are made:

1. To stop issuing the allowance for new wells
2. To decrease the discharge by changing plant pattern and the type of irritation
3. To built underground dams to stop water escape
4. To make artificial recharge

5. Acknowledgment

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6. References

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