Quantitative Model of Underground Waters of Songhor Dessert (Western Iran)

Ronak Gravand 1∗, Tayabeh Mansouri Sarab Badie 2 and Saboora khanjari 3

1 Department of engineering, Collage of civil engineering, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran
Corresponding utor E-mail: rgravand@gmail.com
2 Department of engineering, Collage of civil engineering, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran
3 Department of engineering, Collage of civil engineering, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran

Abstract. Mathematical models are changed into efficient tools during recent years for any studies and water resources makagement. Quantitative model of underground waters of Songhor dessert has been supplied with an area of 56 sqkm located at northeast of Kermanshah province. The long-term average and annual rain in this dessert is equal to 450mm with a reduction up to 240 mm due to various draughts within recent years as well. Quantitative understanding of underground water currencies and various parameters of dessert balance are the major goals for preparing any model for underground waters at Songhor dessert. We studied some managerial options by the use of quantitative model. According to the results for different scenarios including estimation of drilling new wells and also situation of underground waters it was possible to analysis any reduction of %20 in wells at Songhor dessert.

Keywords: Songhor dessert, Underground water basin, Iran

1. Introduction

Optimized utilization of underground water needs exact management and supervision. Any non-stop extraction of underground waters would be lead into a considerable reduction in underground water levels. The most important issue in management of aquifers is control of pumping more than usual time and entrance of various pollutions. As a result, it needs to have correct estimation of aquifer reaction to further effects of discharge, feeding for evaluation of quality and quantity of underground water, hydrologic evaluation of aquifers and finally its long-term development. Because this important issue may cause a complete development and wide range of application for underground water models. The first study about underground water modeling was related to limited difference method in 1968 by California Water Resources Dept. for studying the underground water basin at Los Angeles coastal plain. [1]. Galef could supply quantitative model of Blue Lake Aquifer (Hydro River) by use of Argus ONE at Hambolt part of California and then by making a link to optimized model could supply managerial model of the area [2]. Palma & Bentley could supply relevant model of Leon Chinadga underground water located at Nicaragua [3]. They concluded that numeric models are powerful tools for management of underground & superficial water resource in an area. Ayyaz & Karahan [4] submitted a simulation/ optimization model for recognizing any location of non-permitted wells and also pumping rates [4]. Wang et al. could simulate underground water flow in China northern dessert by the use of MODFLOW and geographical information system [5]. They noticed that water balance in this area was negative.

∗ Corresponding author. Tel.: +980189322043; fax: +980189322043.
E-mail address: rgravand@Gmail.com.
The major goal of this study is to make better recognition of hydrologic system of Songhor desert alluvial aquifer along with a review and data control for determining and calculation of hydraulic parameters of Nazi aquifer to evaluate K(Hydraulic Conductivity), T(Transport) and S(saturated zone) for hydraulic aquifer territories and further optimal management of water resources. Other goals are estimation of future conditions of aquifer with regard to different managerial plans and also recognition of model limitations along with required data for enrichment of models of aquifer in future.

2. Materials & Methods

The study area include more than 541 km$^2$ and lied at longitudes 47°22'-47°51' East and at latitudes 34°40'-34°52' at North. Nearly, 322 (%61) km$^2$ is located in mountainous and 209 (%39) km$^2$ is located in desert parts (Figs 1 and 2).

![Fig. 1: Study scope of Songhor](image1)

![Fig. 2: General view of study scope (Songhor dessert)](image2)

The following is 3-D model of Songhor dessert by the use of modeling protocol extracted from Anderson & Voessner10 [6].

We used relevant layers of Abkhan territory, utilization wells, observed wells, major and indirect rivers, hydraulic guidance coefficient and superficial feed to simulate a conceptual model for dessert (Fig .3).
As mentioned before, there is a 3-D model for underground process in this study called MODFLOW which may use limited difference method for solving partial differential equations. Because a continuous scope of numeric models replaced with a separated scope. Upon supplying of a conceptual model of concerned scope, we should divide it into smaller parts (cells), therefore, local separation is a major step for any models. Our model in the scope of Songhor dessert was divided into 100 *100 (m$^2$) and with blocked center for creation of 3709 active cells and others with inactive ones. (Figure 2-4).

In order to solve differential equation, it needs to divide the time into smaller periods ($\Delta t$). This is with regard to current hydrological data and applied tensions in system and hydrograph of dessert and modeling goals. Time separation of model characterize tension periods and time steps. According to, hydrographs of dessert unit, current statistics and information about current wells (October 2011), the base of our modeling was lower fluctuations and more constant. Time period of calibration in Songhor dessert was modeled from October 2012 for 365 days and accompanied with 12 periods each one with a time step.

Geometry properties information of aquifer (Level stone and ground level topography) and also primary hydraulic load diffused for a point at desert level. For finding the required information which are available for limited points in aquifer to total model limitation and all cells of model net, we used different interpolation equations available in GMS model and its relevant modules (2D Grid, 2D Scatter point). Various interpolation equations were used for determining these properties and related them to all net cells with regard to data distribution and by trial & error method and also drawing of experimental variogram. Usual cryging method was selected for interpolation of data.
Fig. 5: Stone floor level & stone ground level in GIS environment

Fig. 6: A 3-D Schematic of aquifer situation (South view (Exit scope) and southwest)

Fig. 7: Exit model in territorial conditions and a general level
Balance model range was as below, after the first performance.

Table 1: Balance range in first step of performance

<table>
<thead>
<tr>
<th></th>
<th>Flow(m$^3$/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Budget for Zone 1</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>IN:</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td></td>
<td>Constant heads</td>
</tr>
<tr>
<td></td>
<td>General heads</td>
</tr>
<tr>
<td></td>
<td>Rivers</td>
</tr>
<tr>
<td></td>
<td>Wells</td>
</tr>
<tr>
<td></td>
<td>Recharge</td>
</tr>
<tr>
<td>Total IN</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total OUT</td>
</tr>
<tr>
<td></td>
<td>Constant heads</td>
</tr>
<tr>
<td></td>
<td>General heads</td>
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<td></td>
<td>Rivers</td>
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<td>Wells</td>
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<tr>
<td></td>
<td>Recharge</td>
</tr>
<tr>
<td>Total OUT</td>
<td></td>
</tr>
<tr>
<td>SUMMERY:</td>
<td>IN-OUT</td>
</tr>
<tr>
<td></td>
<td>Percent Discrepancy</td>
</tr>
</tbody>
</table>

**Figure. 11:** Balance of underground water after calibration

**Figure. 12:** The rate of violation in calculating balance data out of observed ones

Firstly we may select two hydraulic guidance parameters along with superficial feeding for calibration of testing points. Then we make two Scatter Points named as HK (with minimum rate of 2000m per year) and Rch (minimum rate of 0.01m per year) with suitable local distributions.
Some parameters were selected after calibration for sensitivity analysis. It is PEST Sensitivity method as mentioned in relevant figure. Then, all analysis were made (against 30% of positive & negative changes). Model sensitivity for hydraulic guidance coefficient indicated in following figure:

![Sensitivity analysis against hydraulic guidance parameter](image1)

Table 2: Volume balance of Songhor study scope

<table>
<thead>
<tr>
<th>Balance parts</th>
<th>Entrance</th>
<th>Exit</th>
</tr>
</thead>
<tbody>
<tr>
<td>River</td>
<td>36302949</td>
<td>11641159</td>
</tr>
<tr>
<td>Well</td>
<td>0</td>
<td>3296376</td>
</tr>
<tr>
<td>Feeding</td>
<td>55938.44</td>
<td>0</td>
</tr>
<tr>
<td>Underground Water territorial currencies</td>
<td>3341090</td>
<td>9766653.7</td>
</tr>
<tr>
<td>Total</td>
<td>39703298</td>
<td>39697874</td>
</tr>
<tr>
<td>Entrance- Exit</td>
<td>0.01365931</td>
<td></td>
</tr>
</tbody>
</table>

3. Results

The study area in Songor dessert is unconfined aquifer and according to ten year hydrograph, it has 16 cm drop. The water table balance shows one meter drop.

4. References

Algorithm.


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