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ScienceDirect

Procedia Engineering 154 (2016) 252 – 259

Procedia Engineering

www.elsevier.com/locate/procedia

12th International Conference on Hydro informatics, HIC 2016

A Novel Solution to Define the Optimum Number and Location of New Wells to Improve Groundwater Level Map

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Abstract

Groundwater is one of the major sources of water. Maintenance and management of this vital resource is so important in arid and semi-arid region. Thus, reliable and accurate groundwater measurement is essential to introduce as a basic data for any groundwater management study. Observation wells are adequate tools for monitoring groundwater level. It is clear that more wells lead to better illustration the groundwater map. The aim of this study is to find the appropriate number and location of wells, having maximum effect on improvement of accuracy of groundwater level map. The number of the added wells should be determined by considering both economic restrictions and the amount of improvement that caused by the added well simultaneously. Hence, genetic algorithm was employed to find the optimum number and location of the wells to be added. The objective function of this algorithm is to maximize the gradient of the inverse mean square error per number of added wells.

Peer-review under responsibility of the organizing committee of HIC 2016

*Keywords:*groundwater manegment; optimization; genetic algorithm; monitoring

Introduction

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Peer-review under responsibility of the organizing committee of HIC 2016
doi:10.1016/j.proeng.2016.07.471

Ground water is a major source of supply for domestic, industrial and agricultural purposes, especially in arid and se arid regions. Management of this resource is very important to meet the increasing demand and climate change. Evaluating and analyzing groundwater level play important role in groundwater management and modeling.
Groundwater level is measured by observation wells, so the number and location of the observation wells are two important items that should be considered to improve the accuracy of groundwater level map.

For this purpose there are three methods: physical based, geostatistical and intelligent methods. The physical based models, like MODFLOW, are the main tools for understanding hydrological processes but large quantities of good quality data arerequired to run these models. Furthermore, they are time-consuming and must be well organized. In this regards, it is of high importance to develop a fast and cost-effective method for aquifer simulation, continuously with an acceptable accuracy [1].
The intelligent systems are applied wieldy in hydrology and one of the most important features of them is their ability to adapt to recurrent changes and detect patterns in a complex natural system. Many researchers have advised the intelligent systems as an accurate method. Amongst these researchers are Coulibaly et al. (2001), Daliakpouos et al. (2005),Mohanty et al .(2008), Bisht et al.(2009), Ghadampour et al. (2010), Hosseini and Nakhaei (2015), that they employed Artificial Neural Networks (ANN), Fuzzy and Anfis for aquifer modeling in a variety of basins([2],[3],[4],[5],[6],[1]). The Neural Networks have also been previously applied with success in groundwater level predication [2].

Geostatistical methods are used widely to map groundwater level and they have become to the important technique in hydrology. The accuracy of the results of geostatistical methods have a highly dependence to input data which is coming from observation wells in aquifer. Indeed, each interpolation method comes with some drawback, and the reliability of the results from the interpolation strongly depends on external factors as input data and their spatial and temporal coverage. Kriging methods are one of the powerful interpolation schemes based on geostatistics ([7], [8], [9]). Therefore, kriging methods are widely applied in studying the spatial distribution of groundwater ([10], [11], [12], [13], [14]). Nevertheless, kriging methods usually have a common drawback of overestimate and underestimate, so that this drawback may decrease by adding the number of observation wells. It means that the larger number of observation wells leads to more accurate map.

The aim of the paper is to find the optimal number and location of wells that should be added to the existing well network to minimize mean square error between artificial neural network and kriging with considering condition economic.

1. 2. Material and method

2.1. Case study

Qazvin aquifer which is located in north-west of Iran, by 15559.45×10^6 m^2, annual mean temperature of 13°C, annual precipitation about 0.320 m and cold, dry climate was selected as case study (fig. 1). Monthly groundwater level has been measured by 168 observation wells since 2008 to 2013 that is depicted in figure 1. Based on the monthly average groundwater level, average annual was established for all the wells, which varies from 1408.3m to 1129.5 m with mean value of 1200.9m.