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Identifying the susceptible area of Malikan plain aquifer to contamination using Fuzzy methods

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Expanded Abstract

Introduction

contamination in these resources, and these resources may not be used. Groundwater management, especially in dry regions such as Iran, is essential and this concern becomes further with development of agriculture, industry, population growth and climate changes affecting the quality and quantity of groundwater resources. Hence, groundwater contamination can treat the human health. One of the ways to prevent of groundwater contamination is identifying the vulnerable area of aquifers and management of land use. The assessment of groundwater vulnerability maps requires the application of methods and techniques, based on the hydrogeological knowledge of the region under. Several methods have been devised to vulnerability mapping. Groundwater resources in the Malikan region strongly affected by nitrate fertilizers leachates, due to the presence of grape gardens and intensive agriculture. So in this area, identifying the vulnerable area with the proper method is very important. In this study, improved DRASTIC methods using fuzzy logic and catastrophe theory were used to vulnerability assessment of Malikan plain aquifer.

Materials and Methods

Malekan plain is located in East Azarbaijan Province and northwest of Iran, with an area of approximately 450 km^2 (Fig. 1). This region is one of the very active agricultural cultivated areas with water demands supply by groundwater resources. In recent years, groundwater quality of this area is encountered with degradation problem. According to farming and existing of grape farms in this region and intensive use of fertilizers and manure, the groundwater nitrate concentration of the aquifer is high. The aquifer of this plain is unconfined and formed by old and recent alluvial terraces, alluvial fans, and fluvial sediments. The maximum thickness of the alluvia has been reported to be in the central and urban area of Malikan. To evaluate the quality of groundwater resources, especially the assessment of nitrate anomalies in groundwater of the Malekan plain, 27 samples were collected from groundwater resources, and hydrochemical analysis was carried out in Hydrology Laboratory of Tabriz University.

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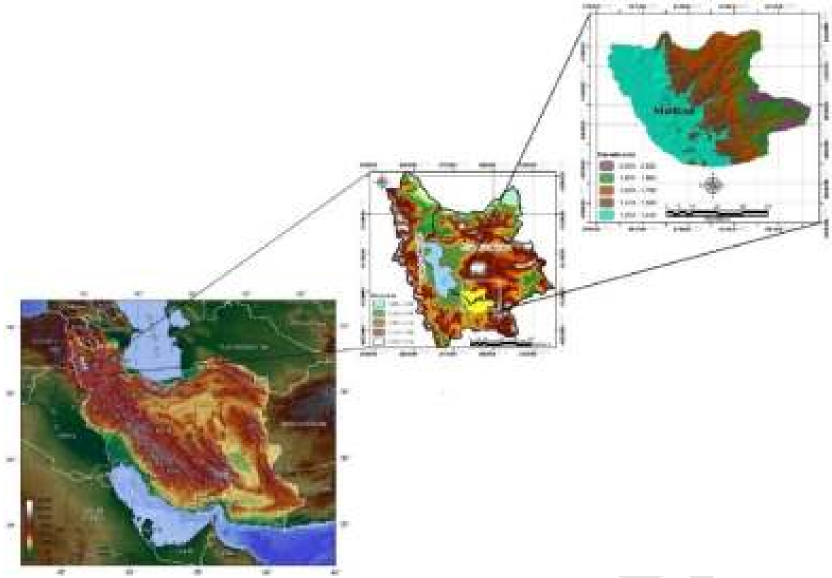
Fig. 1. Study area and sampling points

DRASTIC model has been used to map the groundwater vulnerability to pollution in many areas. Since this method is used in different places without any changes, it cannot consider the effects of pollution type and characteristics. Therefore, the method needs to be calibrate and correcte for a specific aquifer and pollution. DRASTIC model was improved with several methods such as artificial neural network and catastrophe theory (Sadeghfam et al., 2016; Baghapour et al., 2016). In this study the catastrophe theory and fuzzy logic is proposed for groundwater vulnerability.

Results and Discussions

To identify the groundwater vulnerability, the maps of depth to water table, net recharge, aquifer media, soil media, topography, impact of the vadose zone, and hydraulic conductivity are prepared in ArcGIS. The groundwater depth map are prepared by interpolating monthly groundwater depth average of 27 observation wells by kriging method. Catastrophe theory based multi-objective decision-making evaluation system is applied to groundwater vulnerability assessing. Butterfly, swallowtail, cusp, dovetail catastrophe, hyperbolic umbilical, parabola umbilical and fold are seven types of catastrophe models (Wang et al., 2012). The catastrophe theory is applied to assess groundwater vulnerability map using following steps: (i) processing of data layers, (ii) normalization of data layers, (iii) computation for groundwater vulnerability assessment, and (iv) performing the weighted overlay analysis. After selecting the catastrophe fuzzy membership functions for each layer, the weights of data layer should be estimated. In this step, the DRASTIC parameters are weighted with respect to complementary principle and mean value of normalized control parameters, which in the complementary principles, the mean value of control parameters shows the state of system. In the fuzzy logic method, the vulnerability values were corrected in the training stage and then, by training the fuzzy models, validation was performed using vulnerability and nitrate values. Based on the results of fuzzy logic models, in the study area, Sagno method, with lowest error and the highest correlation index with nitrate, have a high ability to optimization of DRASTIC method. Figure 2 shows the vulnerability map of the Malikan plain, using general DRASTIC, fuzzy logic and catastrophe theory.

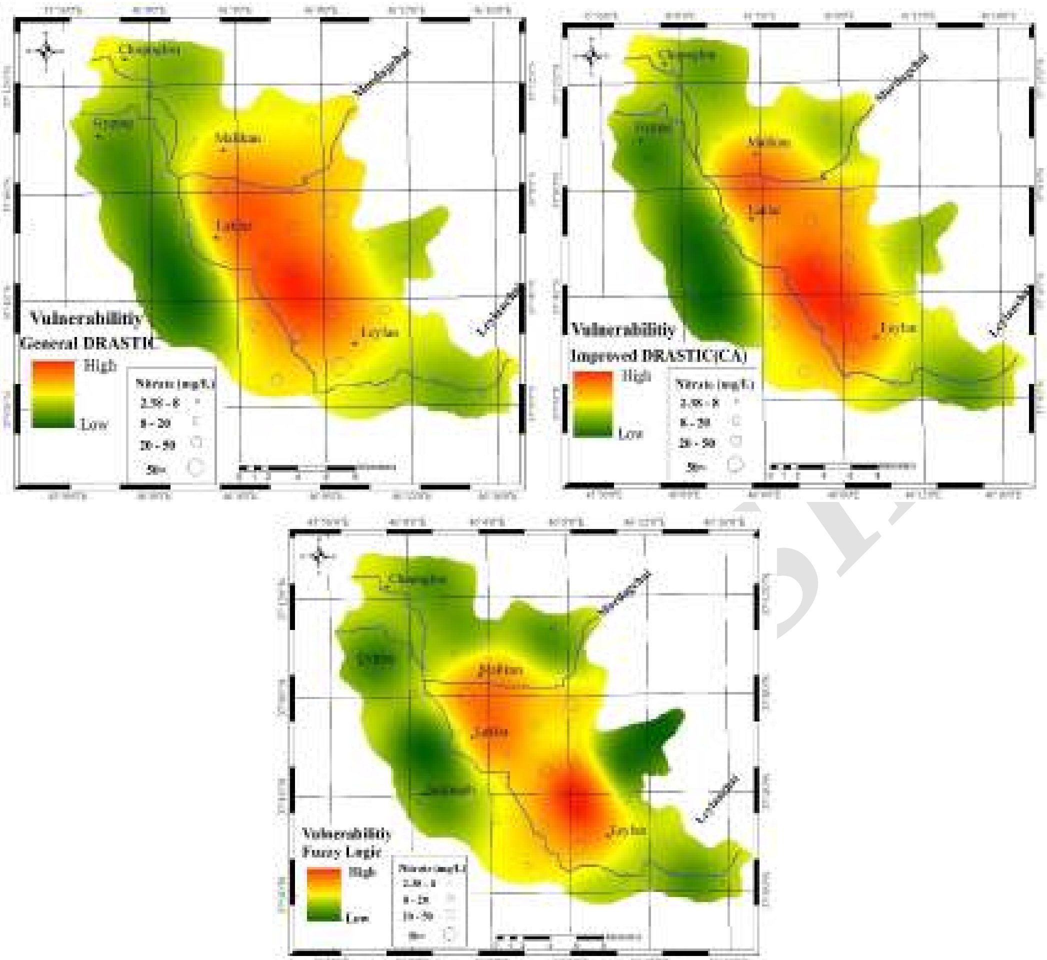

Fig. 2. Vulnerability map using general DRASTIC, fuzzy logic and catastrophe theory

Conclusion

In this study, Fuzzy logic and Catastrophe theory methods using geographic information system (GIS) was applied to evaluate groundwater vulnerability in study area. For optimization, DRASTIC parameters including seven hydrogeological parameters and the value of the vulnerability index respectively are defined as the input and output of the models. Validation of the models was performed using nitrate concentration data and correlation coefficient with the vulnerability index in the region. The results of models showed that the improved DRASTIC model using catastrophe theory with higher correlation index (CI) with nitrate concentration has provided a better result than the fuzzy logic for the aquifer vulnerability assessments. Based on catastrophe theory, the 56%, 23%, 21% of aquifer respectively located in low, medium and high vulnerability area, and central parts of plain was identified as a high vulnerable zones.

Keywords: aquifer, Catastrophe theory, Fuzzy logic, Malikan plain, vulnerability.