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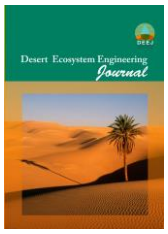

Assessment of some Artificial Intelligence (AI)-based Models for Groundwater Quality Prediction

(Case Study: Gero plain)

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Introduction

Today, a significant portion of the water consumption in Iran, especially in the drinking sector, is provided by water resources. Exploitation of groundwater resources requires knowledge of the quantitative and qualitative status of aquifers. By determining the chemical quality of groundwater, an estimate of the health status of these water resources can be obtained and, depending on its state, the type of use is determined. In this regard, direct and indirect methods can be used to understand the qualitative characteristics of water. Direct methods, despite their high precision, require a high size of observational data, involves substantial time and cost. Hence, numerous indirect methods have been developed for simulating natural systems and estimating their parameters using a computer based on complex calculations. The main advantage of these methods is the ability to learn time series and prediction. One of these methods is modeling or hydrological simulation. The modeling of groundwater quality is an important tool for planning and decision-making in the management of water resources. The goal of this research is to identify the ability of intelligent model of Support Vector Machines (SVM), Artificial Neural Network (ANN), and Adaptive Neuro-Fuzzy Inference System (ANFIS) for modeling groundwater quality variables (EC, SAR, TDS, and TH) in Gero plain and zoning these variables. Therefore, it can provide an appropriate management tool for controlling quality parameters for drinking and farming.

Material and methods

In this study, data from 14 wells over the 2008-2016 period was used in order to model the variations in quality variables of Gero plain groundwater. The observed values for Na, Mg, Ca, SO4, Cl, and HCO3 are considered as independent variables and values of EC, SAR, TDS, and TH are considered as dependent variables. An SVM, an ANN, and an ANFIS design were used to model groundwater quality. Input data are randomly divided into two sets such that 80% of data are assigned to the training set and the remaining data (20%) form the test set.

Results

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Results showed that the ANFIS system had the best performance in the estimation of EC (R^2 = 0.99, RMSE=109.13, CE=0.99), SAR (R^2 = 0.98, RMSE=0.28, CE=0.98), and TH (R^2 = 0.99, RMSE=0.49, CE=0.99) among considered methods for the modeling of groundwater quality. Results also indicated that the ANN had the best performance in estimating TDS (R^2 = 0.99, RMSE=109.13, CE=0.99). Furthermore, Schoeller and Wilcox water quality classifications, for drinking and agricultural water, were respectively employed to perform groundwater quality zoning based on outcomes of the considered methods. According to Schoeller classification, TDS has three classes: inappropriate (21.1%), bad (74.59%), and non-dirking (4.31%) and TH variable has four class: good (0.84%), acceptable (23.48%), inappropriate (67.55%), and bad (8.16%). According to Wilcox classification, EC has three classes: excellent (9.41%), good (89.79%), middle (0.8%) and SAR has two classes: excellent (19%) and good (81%).

Discussion and Conclusion

ANFIS for a better estimation of EC, SAR, and TH variables outperforms two models of ANN and SVM. The ANFIS system, using the if-then rules, describes that these rules are implemented in a network structure that can be used for learning algorithms used in ANN. Due to this structure, the fuzzy-comparative neural network model has more transparency for analysis and interpretation. The zoning of qualitative variables (TDS and TH) based on the classification of Schoeller drinking water showed that in the TDS variable, the groundwater quality has three classes: bad, inappropriate, and non-drinkable, with the most inadequate plain, southeastern plain bad status and the west of the plain has a terrible situation. The TH zoning map presents that the plain is in good, acceptable, inappropriate, and bad classes. The most part of the plain is in the inappropriate class, the west of the plain in the bad class, and the southeast plain is in an acceptable class. The results of zoning the variables EC and SAR based on the Wilcox agricultural classification showed that groundwater quality is acceptable four agricultural purposes. Therefore, it is essential to take measures to improve the quality of drinking water in the region.

Keywords: Garoo plain, support vector machine, artificial neural network, adaptive neuro-fuzzy, zoning and groundwater quality.