Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 53(1) (2021) 75-78
DOI: 10.22060/ceej.2018.14258.5605

Use of Artificial Neural Network and Imperialist Competitive Algorithm to Evaluate the Groundwater Quality of Jolfa Plain for Various Uses

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ABSTRACT: Assessment of groundwater quality and quantity are important in the management of these resources. The use of modern methods, including ANN and evolutionary algorithms in estimating water quality, due to its high speed, convergence, and efficiency, saves and reduces costs and the best management. The main purpose of this study is to evaluate the results of the chemical analysis of groundwater samples from 14 wells in the Jolfa plain and also estimate the groundwater quality parameters using an imperialist competitive algorithm (ICA) and ANN. Therefore, groundwater quality parameters include TDS, EC, and SAR estimates using the imperialist competitive algorithm (ICA) and ANN, and groundwater resources quality in terms of drinking, agriculture, and industry were examined by Wilcox, Schuler, and Piper and standards. A correlation coefficient of (R2) 90%, indicates the acceptable accuracy of ANN compared with the ICA algorithm in estimating groundwater quality parameters. By using different diagrams the results show that the hardness of samples is too much and not suitable for drinking. It should also be noted that very high hardness and corrosion of sample, water not be used in industry. The salinity of 7 samples is very high and according to classification is located in the C4S2 class and not suitable for agricultural consumption.

Review History:
Received: 3/29/2018
Revised: 6/24/2018
Accepted: 7/26/2018
Available Online: 8/15/2018

Keywords:
Agricultural
ANN
Drinking
Imperialist Competitive Algorithm
Water Quality

INTRODUCTION

Groundwater resources are one of the best and in some cases the only solutions to the problem to providing drinking water and agriculture in arid and semi-arid areas, including Iran. The reduction of water level and water quality due to increased utilization of groundwater resources and a low level of natural nutrition is recently increasing.

In recent years, increasing salinity and reducing groundwater quality have been considered as one of the most important environmental issues in the world. Due to the infiltration and mixing of pollutants, Infiltration of pollutant waters into aquifers is one of the problems that has been exacerbated by human activities and industrial growth that led to reduce the quality of groundwater.

Today, water resources are one of the basics of sustainable development, besides, water quality is also considered an important parameter. Therefore, water quality parameters are components that should be carefully predicted and simulated in the programming.

The evolutionary algorithms and artificial neural networks have shown satisfactory results in the modeling of non-linear complex systems in water resources management issues, which have been reported to various areas by researchers. Artificial neural networks and evolutionary algorithms with compatibility and unpredicted changes are an appropriate alternative to physical and regression models for estimating the behavior of water resources.

Due to the role of sodium absorption ratio (SAR) in soil management and stability, the estimation of this parameter in groundwater is very important. The electric conductivity parameter (EC) is also a major parameter in the monitoring of drinking and agricultural water quality. This parameter is directly related to the amount of water salinity, sodium absorption, and drinking water quality [1]. TDS is also a very effective parameter for creating the drinking water tasted.

Various studies have been conducted in the groundwater level prediction, including:

Emami et al, (2017) Evaluated imperialist competitive and genetic algorithm for estimating groundwater quality parameters in Bostanabad plain. The validation of the simulation with the ICA model showed that MSE in the testing sample for SAR and chloride were 0.0134 and 0.0098, respectively. Also, R^2 of validity for SAR and chloride were 0.93 and 0.952, respectively.

Due to the literature, and the Jolfa plain is one of the most important plains in the northwest and the most important source of water supply to various sections of its neighboring areas, estimating and modeling the groundwater quality in this plain is very necessary. Therefore, the purpose of this study was to introduce and apply the ICA algorithm and compare its results with artificial neural network (ANN) and Wilcox,

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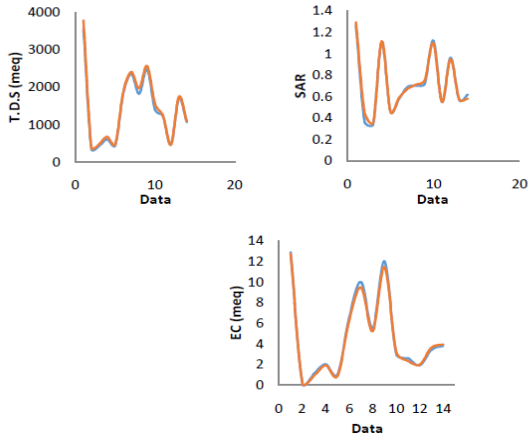

Fig. 1. Observed and estimated values of groundwater quality parameters of ICA.

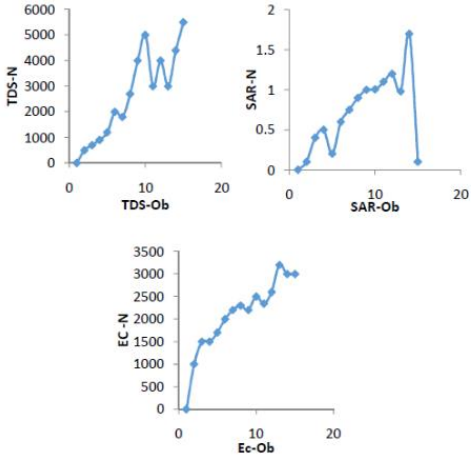

Fig. 2. Observed and estimated values of groundwater quality parameters of ANN.

Schuler, and Piper diagrams in estimating and optimizing the water quality parameters.

2. MATERIAL AND METHODS

2.1. Case Study

Jolfa plain is located in the northwest of East Azerbaijan between 45° 17' and 46° 31' east longitude and between 38° 39' and 39° 2' northern latitudes. It leads to the Aras River and the Nakhchivan, Armenia, and Azerbaijan republics. The area of this plain is 1670.31 km^2, which leads from the east to Kaleybar and the south to Marand and Ahar cities.

2.2. Preparation of Data

To determine the chemical of groundwater quality in the case study used information from 14 wells in June 2014 and chemical chemistry tests, cations, anions, acidity (pH), electrical conductivity (EC), TDS, and hardness of the water.

2.3. ICA Algorithm

Pseudocode for the proposed algorithm as follows [2-3]:

1) Select some random points on the function and initialize the empires.

2) Move the colonies toward their relevant imperialist (Assimilating).

3) If there is a colony in an empire that has a lower cost than that of imperialist, exchange the positions of that colony and the imperialist.

4) Compute the total cost of all empires (Related to the power of both imperialists and their colonies).

5) Pick the weakest colony (colonies) from the weakest empire and give it (them) to the empire that has the most likely to possess it (Imperialistic competition).

6) Eliminate the powerless empires.

7) If there is just one empire, stop, if not go to 2.

2.4. Optimization using Artificial Neural Network (ANN)

All optimization problems consist of two stages of modeling and planning including, the formation of the objective function, constraints, and limitations (first stage, modeling), and the determination of the optimal conditions to achieve the ideal solution (second stage, planning). An artificial neural network consists of a set of neurons with internal links with one another, which can provide output responses based on the input data and information. Neural networks are usually created in a layered and regular manner. The first layer, in which the input data are entered, is the input layer. The middle layers of the hidden layers and the last layer, which provides the output responses are the model, is the output layer [4].

2.5. Wilcox and Schuler Methods

The Wilcox classification method and the use of its diagram are the most practical method for categorizing agriculture in hydrological studies because in the Wilcox diagram, the horizontal axis is the water salinity (µm/cm) and the vertical axis in the sodium absorption ratio (SAR) belongs. In the Schuler diagram, for each of the cations (Na, K, Mg, and Ca) and also the water hardness degree (TH), a separate axis is considered for each of them, which by its determination in the laboratory and connecting their respective points on these axes, can see the drinking water hardness balance.

3. RESULTS AND DISCUSSION

The data used in this study is a total of 168 data. 148 data of current data was used for training the network and 20 data calibrations of the network. For the ICA algorithm, the numerical code was used in Matlab software to estimate SAR, EC, and TDS. To determine the water quality for industrial uses, the lingual coefficient (SI) of the water sample used according to the following equation:

$$SI = 2pH_s - pH \quad (1)$$

In Figs. 1 and 2, observed and estimated values of groundwater quality parameters are shown using two ICA and ANN models.

4. CONCLUSIONS

The results of the ICA and ANN models showed that a good match with the observed data, which shows the efficiency of these methods. The high correlation coefficient (R2) obtained from ANN in comparison ICA algorithm indicates that the ability and the accuracy of ANN methods for estimation of groundwater quality parameters. The results of the chemical analysis of Jolfa plain groundwater by Wilcox, Schuler, and Piper diagrams also showed that the water of this plain is not very good for drinking and difficult to food digest.

REFERENCES

[1] M. M. Mirsanjouri, F. Mohammadyari, R. Basiri, F. Hamidipour, Modeling the EC, SAr and TDS in groundwater using artificial neural network (case study: Mehran and Dehloran Plain), *Human and Environmental Quarterly Journal*, 42 (2015) 1-12. (In Persian)

[2] S. Emami, M. Hemmati, H. Arvanaghi, Evaluation and comparison Imperialist Competitive and Genetic algorithms in Estimation of groundwater quality parameters, *Journal of Hydrogeology*, 292 (2017) 44-53. (In Persian)

[3] E. Atashpaz-Gargari, C. Lucas, Imperialist competitive algorithm: An algorithm for optimization inspired by imperialistic competition, *IEEE Congress on Evolutionary Computation*, (2007) 4661–4667.

[4] M. B. Menhaj, Computational Intelligence, No. 1, The Basic of Artificial Neural Networks, Amirkabir University, (1998). (In Persian)

HOW TO CITE THIS ARTICLE

S. Emami, R. Norouzi Sarkarabad, Y. Choopan, Use of Artificial Neural Network and Imperialist Competitive Algorithm to Evaluate the Groundwater Quality of Jolfa Plain for Various Uses, Amirkabir J. Civil Eng., 53(1) (2021) 75-78.

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