Advances in Computer, Signals and Systems (2020) 4: 25-35
Clausius Scientific Press, Canada
DOI: 10.23977/acss.2020.040105
ISSN 2371-8838

Classification of Groundwater Quality using Artificial Neural Networks in Safwan and Al-Zubayr in Basra

Ahmed Naser Ismael[1,a], Hamid Ali Abed [2,b] and Majida Ali Abed [3,c]

[1]Management Information Systems Department, Basra University, Al-Basrah, Iraq
[2] Computer Science Department, Basra University, Al-Basrah, Iraq
[3] College of Computers Sciences, Tikrit University, Tikrit, Iraq
a. Ahmed.ismael@uobasrah.edu.iq, b. 865.hamid@gmail.com, c. Majida.alasady@tu.edu.iq

Abstract: Groundwater in the southern region of Iraq is a completed resource for irrigation and industry. In this study, the groundwater quality of more than 60 wells in the Safwan area and Al-Zubayr district in Basra was calculated using artificial neural networks with feedback. The variables used in the proposed classification and verification model are the physical and chemical variables of groundwater. The taxonomy model demonstrated good performance and accurate taxonomic capacity to facilitate the development and implementation of more effective and sustainable groundwater management strategies in the study area.

1. Introduction

Groundwater is one of the basic requirements for human survival on Earth. As the world's population increases, it is necessary to provide safe and free water from all contaminants. groundwater is one of the major sources of drinking in many urban and rural areas of the world and is an important source of water in the agricultural and industrial sectors. The groundwater level is an indicator of groundwater availability, flow, and physical and chemical properties. The term groundwater management is used to refer to a formal methodology capable of improving groundwater decisions[1]. groundwater management seeks to minimize the impact of salt water intrusion, hazardous waste, pesticide use, or other threats to the quality of groundwater. groundwater systems are characterized by complex, nonlinear, multidimensional and random features that are controlled by natural or anthropogenic factors, complicating dynamic predictions. Depending on Tigris and Euphrates rivers, Iraq is relatively rich in its water resources compared to neighboring countries until the 1970s. Syria and Turkey began to build dams on Tigris and Euphrates during the 1970s, resulting in a significant decline in the flow of Euphrates as well as deterioration in the quality of its water. This fact has highlighted further concern about future water quotas and their troubling implications for national security and strategies. Water resources in Iraq can be divided into (precipitation, surface water, groundwater)[2].

Be advised that papers in a technically unsuitable form will be returned for retyping. After returned the manuscript must be appropriately modified. The rainfall is either in the form of rain or snow in the cold and high areas and because of the nature of the desert and semi-desert climate, which covers about 80% of the area of Iraq can be explained the distribution of the total annual rainfall in Iraq, amounting to 100 billion cubic meters as in figure (1). The surface water in Iraq consists of rivers, runways, tributaries, seasonal valleys and natural lakes. The area of the actual recharge basin and the annual revenues of the Tigris and Euphrates rivers in Iraq are illustrated in figure (2).

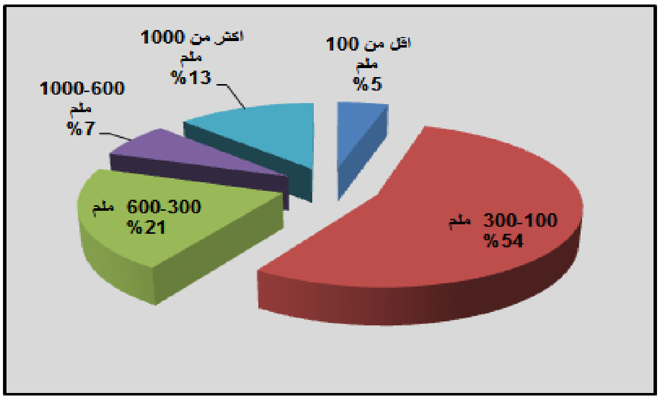


Figure 1: Total annual rainfall in iraq, amounting to 100 billion cubic meters m 3

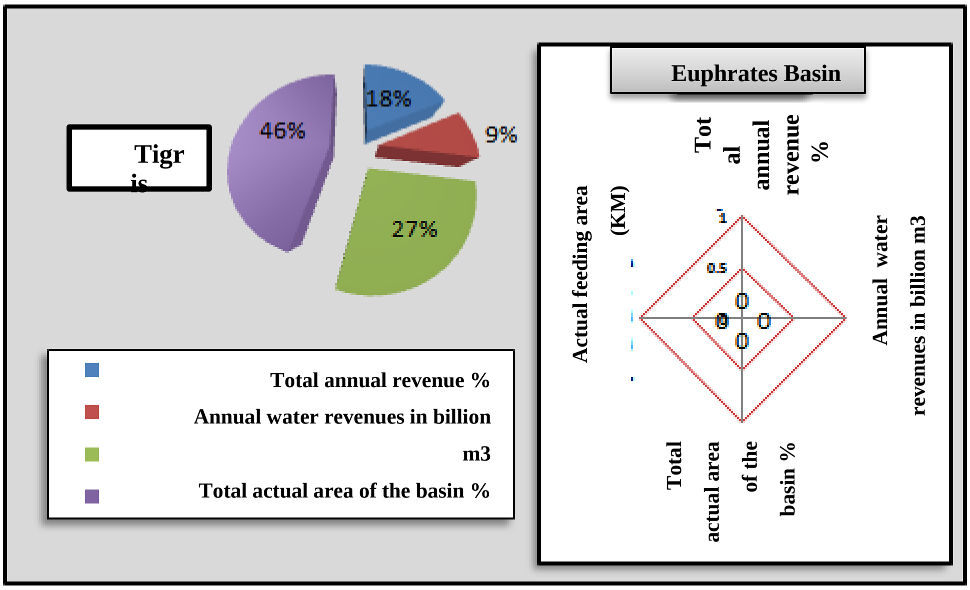


Figure 2: Area of the actual recharge basin and the annual revenues of the Tigris and Euphrates rivers in Iraq.

Groundwater resources are another important source of human resources and are divided into two types (renewable groundwater and non-renewable groundwater). According to some studies, half of the irrigated areas in central and southern Iraq were severely damaged by water logging and salinity in 1970, as the southwestern part of Basra (Al-Zubayr and Safwan) is devoid of any surface water resource that can be relied upon to meet the needs of different populations. Groundwater, therefore, has great importance. The aquifer in southern Iraq is saline and very close to the surface so that it is sufficient for some uses [3].

Groundwater is rich in mineral content from surface water because it has a large capacity to dissolve various minerals. Its chemical composition depends on the type of rock that passes through the water and the quality of water contained in these rocks. Groundwater contains various chemical elements, most notably ions that combine with some mineral elements to be soluble salts. The electrical connection is the water's ability to conduct an electrical current, which is a function of dissolved solids in the water and measured in micromosomes/ cm and E.C. is a shortcut for Electric Conductivity [4]. The high value indicates that the amount of soluble salts is high depending on the temperature, so that the greater the amount of dissolved salts and the temperature increased the electrical connection to the groundwater as shown in table I.

Table 1: World classification of irrigation water

Electrical connection	**class**
Less than 250	Excellent for drinking human, animal and watering plantations
250 – 750	Good for watering types of plants, fruits and vegetables
750 – 2000	Accepted special types of vegetables such as tomatoes
2000 – 3000	Used in industry, especially pharmaceutical industry
More than 3000	Used in industry, especially oil industries

The main constituents of drinking water depend on the major ions, total salts, organic compounds, biologics and irradiation. The water may be chemically safe and not biologically suitable for containing pathogenic or pathogenic organisms. There are several parameters that have been developed as standard specifications for the validity of water for human drinking [5]. These include the salinity limits and concentration limits of the positive and negative ions (WH,1983) and Iraqi specifications (IRS,1989), as shown in table II.

Table 2: International, Iraqi and American specifications to determine the validity of drinking water.

1996.IQS (Mg.L-1)	**،1996 WHO (Mg.L-1)**	**USEPA,1975 (Mg.L-1)**	**Parameter**
1000	1000	1000	TDS
6.5 – 8.5	6.5 – 9.5	-	pH
500	-	500	(TH)
-	-	20	K+
200	200	200	Na+
50	50	125	Mg+2
150	200	200	Ca+2
250	250	250	Cl-
250	250	250	S04-2
-	-	500	HCO3
50	50	-	N03

Groundwater management has been studied by optimizing sites and pumping wells by some researchers. Study of groundwater management dealt with the management of groundwater supply and the elimination of waste disposal. Later, digital models and nonlinear programming techniques were used to study groundwater management methodology. In order to develop the digital model of groundwater, the basic data should include: terrain, geological coverage, soil characteristics, land use map, vegetation distribution, evaporation information, hydrological and climatic evidence, and so on. Extensive data from numerical models require a significant reliance on data and sensitivity [6].

In recent years, artificial neural networks have been used (Artificial Neural Network) (ANN) for prediction purposes in many fields of science and engineering. Several studies have been conducted in the field of groundwater level prediction when the required data are available. Most of the researches used (ANN) alone to predict the level of groundwater. But the current study included a factor analysis side by side to increase the accuracy of the classification of groundwater quality in the study area Al-Zubayr and Safwan in Basrah. As groundwater levels have shown a rapid decline in the past decade due to over-exploitation of domestic, agricultural and industrial needs, careful classification is essential for better planning to conserve groundwater resources [7].

2. Artificial Intelligence (ANN)

Artificial Intelligence (ANN) applications have been deployed in recent times, and they are an appropriate tool for solving many problems, notably distinguishing, classifying and using patterns as an alternative to traditional models. Researchers in the field of artificial neural networks use multiple types and techniques in the design of neural networks, including the Feed-Forward Network and the Feed-Backward Network. [8] Artificial neural networks are made up of simple processing units called the neuron or node that mimic the natural neuron.

Each contact between these cells is determined by values called Weights, which store information to make them available to the user by controlling Weights. In general, each artificial neural network arranges layers from a group of artificial cells: input layer, hidden layer or layers, hidden layers, output layer. There are many types of artificial neural networks: Networks Neural Forward Feed, Networks Neural Back Feed, and Networks Neural Associative Auto.

3. Error Back Propagation Artificial Neural Network (EBPANN)

Error Back Propagation Artificial Neural Network was first described by Paul Werbos in 1974, and further developed by David E. Rumelhart, Geoffrey E. Hinton and Ronald J. Williams in 1986 [9]. It was Common supervised learning technique; it’s used for pattern recognition, function approximation, prediction and Mapping tasks. The Error Back Propagation Artificial Neural Network algorithm has been widely used and a popular technique as a learning algorithm by examples in feed forward with a finite number of pattern pairs consisting of an input pattern and a corresponding (target)output pattern. Multiplayer neural networks each layer consists of one or more cells (neurons), each cell (neuron) in layer receives input from each cell (neuron) in the previous layer, and output to each cell (neuron) in the following layer. The Back propagation is applied to feed forward artificial neural network with one or more hidden layers this algorithm is different than others in the way in which the weights are calculated during the learning phase of the network. Zweiri, Y.H. et al [10] minimized the total squared error of the output based on Error Back Propagation Artificial Neural Network. The important points in the Error Back Propagation Artificial Neural Network are:

- Networks in layered structure (multi-layers' network).
- The value of all weights are random
- Learns by examples and learning process is done through sequential mode and batch mode
- Error calculated on output layer and propagated back to hidden layers.
- Consists from two parts forward part (calculated output) reverse pass (actual output).
- The input and its corresponding output(target)are called a training Pair.

- Weight changes calculated using learning rate (η).

Error Back Propagation Artificial Neural Network has some problems which include network paralysis, local minima and slow convergence these problem occur when the network always change the weights, modify value of weights to very large value during the training operation. There are a number of solutions for these problems. The important one is very simple and that is to change the weights to different random numbers and try training again. Another solution is to add “momentum” to the weight Change. This means that a weight changes from iteration to iteration at any given time depends not just on the present error, but also on preceding changes. Further training of the Error Back Propagation Artificial Neural Network is continued till the desired classification performance is reached. The algorithm consist of two parts first part is forward propagation, second part is reverse propagation which explain below the two parts and Multilayer feedforward networks are trained using Error back propagation Artificial Neural Network learning algorithm as shown in Figure (3) [10].

- Forward Propagation part:

Step 1: Compute δ_i^l in the output layer ($oi = y_i^l$)

$$\delta_i^l(c) = g'(h_i^l)\left[d_i^w(c) - y_i^l(c)\right] \qquad (1)$$

Where represents the net input to the ith cell in the Ith layer, and g’ is the derivative of the activation

function g.

Step 2: The error of a character is calculated

$$E(c) = (1/2)\sum\left[d_i^w(c) - \delta_i^l(c)\right]^2 \qquad (2)$$

- Reverse Propagation part:

Step 3: Compute the deltas for the preceding layers by propagating the errors backwards;

$$\delta_i^l(c) = g'(h_i^l)\sum_j w_j^{l+1}\,\delta_i^{l-1}(c) \qquad (3)$$

Where w_j^{l+1} the weights and the following equations define the change in the weights

$$w_{kj}^l\,(t+1) = w_{kj}^0\,(t) + \eta\,\delta_{pk}^0\,i_{pj} \qquad (4)$$

$$w_j^{l+1}\,(t+1) = w_{ji}^l\,(t) + \eta\,\delta_{pj}^l\,x_i \qquad (5)$$

Step 4: Update weights using equation (4):

$$\Delta w_{ji}^l = \eta\;\delta_i^l\,y_i^{l-1} \qquad (6)$$

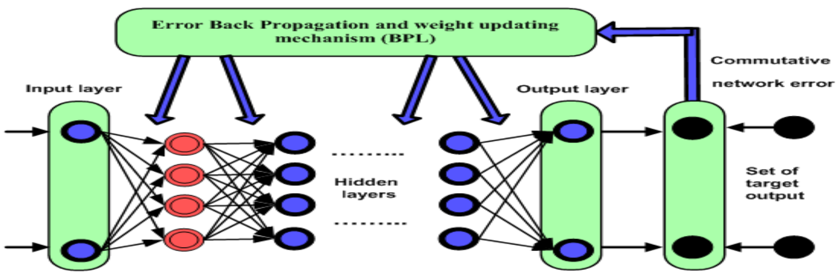


Figure 3: Multilayer feed-forward neural network.

4. Results and Discussion

In this paper model of a neural network with feedback was constructed Error Back Propagation Artificial Neural Network (EBPNN) In this study, a model of a neural network with feedback was developed. The 60 groundwater wells in the study area (Safwan 60 wells) and Al-Zubayr (60 wells) can be classified according to physical and chemical characteristics (13 different parameters) to 5 varieties) and commensurate with the structure of the neural network that fits the problem to be solved. The actual area of study was identified as Al-Zubayr and Safwan in Basra, which is represented by the topographic map and surveying the field of field research as in figure (4) to identify the wells and heights of the study area. The topography of the region and the contours of the area were illustrated in figure (5). The information on the artesian wells was obtained from the University of Basrah, Faculty of Sciences, Geology Department, available in the study area, and 60 wells were identified in the study area, which were determined according to length and width coordinates.

Figure 4: Iraq map showing location of study area in addition to a map showing the topography of the paper area.

Safwan Area **Zubair Area**

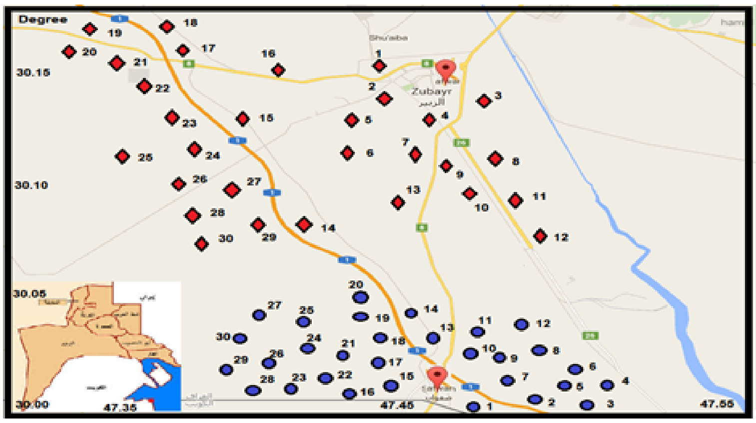


Figure 5: A map of the study area showing the groundwater wells in the area of Safwan and Zubair

- Data obtained from the paper area were divided into training data and test data as follows:
- Data entry of 60 wells for the purpose of training (2500 for different months).
- Data entry of 60 wells for the purpose of testing (60 value for different months).

The neural network algorithm was used with back-error. The neural network has the following characteristics: one input layer, a number of variable hidden layers (30-20-10), the number of cycles is (25-50-100) cycles, the error ratio equals 0.01, one output layer. The model of the neural network with backward regression of error was developed in this paper. The model was trained, validated and tested within a statistical calculation environment. The accuracy of the grid was evaluated using the square root of mean error squares between the measured and predicted values as follows:

$$\boldsymbol{RMES} = \sqrt{\left(\sum_{k=1}^{n}(z_s - z_o)^2\right)/n} \qquad (7)$$

where n represents the number of samples.

The backward regression in training is tested in neural networks as figure (6) is a multilayered network. The algorithm (Back Propagation) means a lower recalculation of the neural network for optimal training.

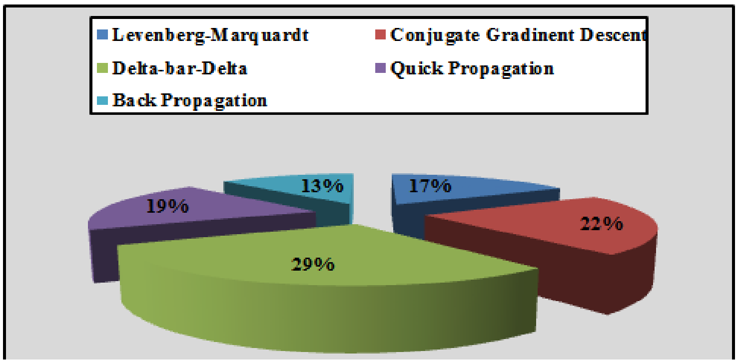


Figure 6: Selection of an algorithm and the square root ratio of the average error boxes for each algorithm.

Artificial neural networks are effective tools when used in classification. It is necessary to identify the variables introduced in the training process and to determine the relationships between inputs and outputs in the proposed neural network. A set of input and output values defined as (Input-Output pair). These pairs are divided into three groups. The first and second groups are designated as (training sets) and (Validation sets) which are used to achieve (conduction weights) or (weighting coefficients).

The data entered into the training phase, which represents the groundwater information for the study area, is 60 wells (60 wells in Al-Zubair and 60 wells in Safwan). In this study, we study and analyze the values of concentrations of the physical and chemical variables of groundwater (Calcium ion, Magnesium ion, Sodium ion, Potassium ions, Sulfuric ion, Chloride ion, Bicarbonate and Carbonate ion, Silicon ion, Nitrite ion, Electrical Conductivity, total dissolved Salts, Hydrogen) as in figure. (7) of the 60 wells in the study area.

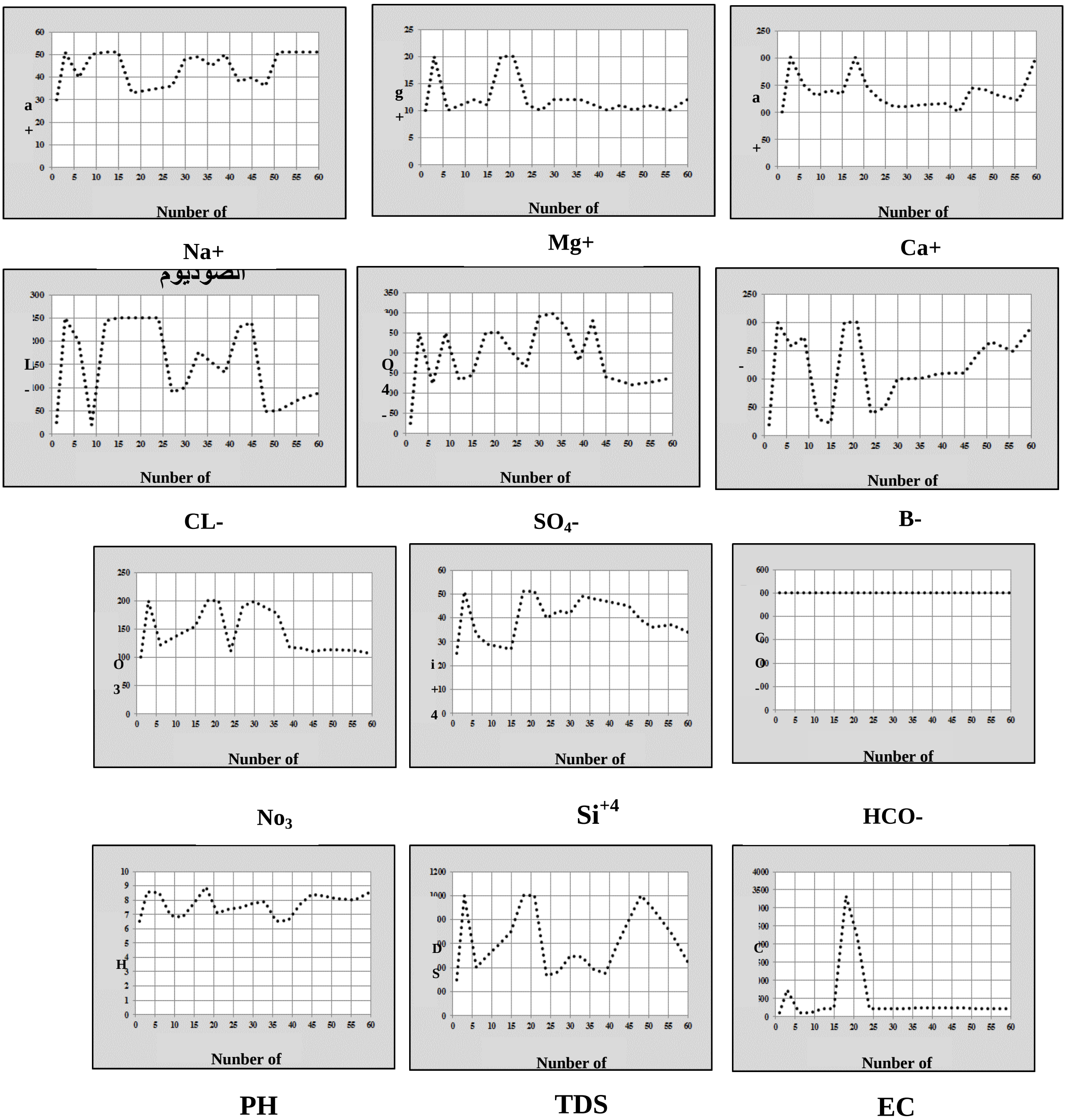


Figure 7: Values of concentrations of physical and chemical variables of groundwater in the study area.

Several layers (one input layer, Hidden layers variable number, and one output layer) were used for the neural network used. Various neurons were tested in hidden neurons, based on the RMSE value; six neurons were selected in hidden layers. Figure (8) shows the results of this comparison. The neural network of six neural cells in the hidden layers produced the smallest RMSE error in this paper.

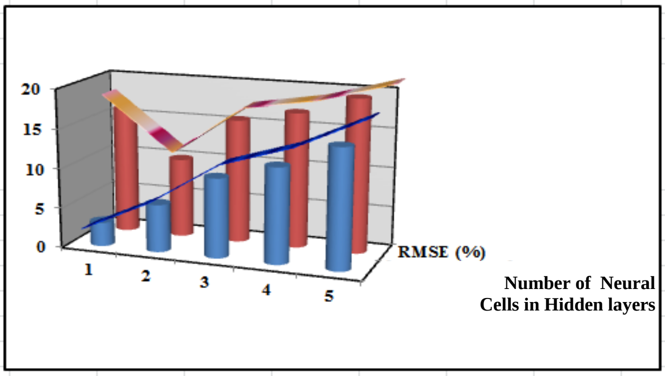


Figure 8: Results of the study to determine the number of neurons in hidden layers based on the percentage of RMSE values.

After the network has been successfully trained, the weights are determined and the test data is used to evaluate the network performance by feeding the test group data to the network and then comparing the network output with the desired output. Results were presented in a statistical way. Regression analysis is used to measure the degree of correlation between actual output and network output. The correlation coefficient value (R = 1) gives an indication of an ideal model while (R = 0) indicates a very bad model as in figure (9).

Figure. (9) shows the linear correlation between the results of the neural network. The correlation coefficient for the data being tested was 92.51%, while the mean error for the same group was 11.3. The results obtained showed a good performance of the neural network model with the back decline of the error in the classification of the quality of groundwater in the study areas (Al-Zubayr and Safwan) in Basra as in figure (10).

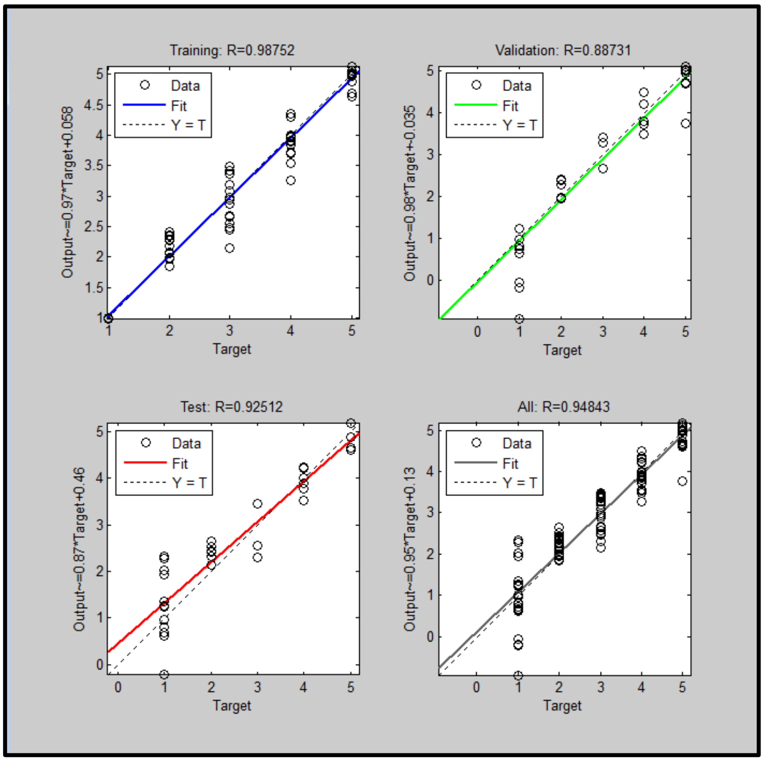
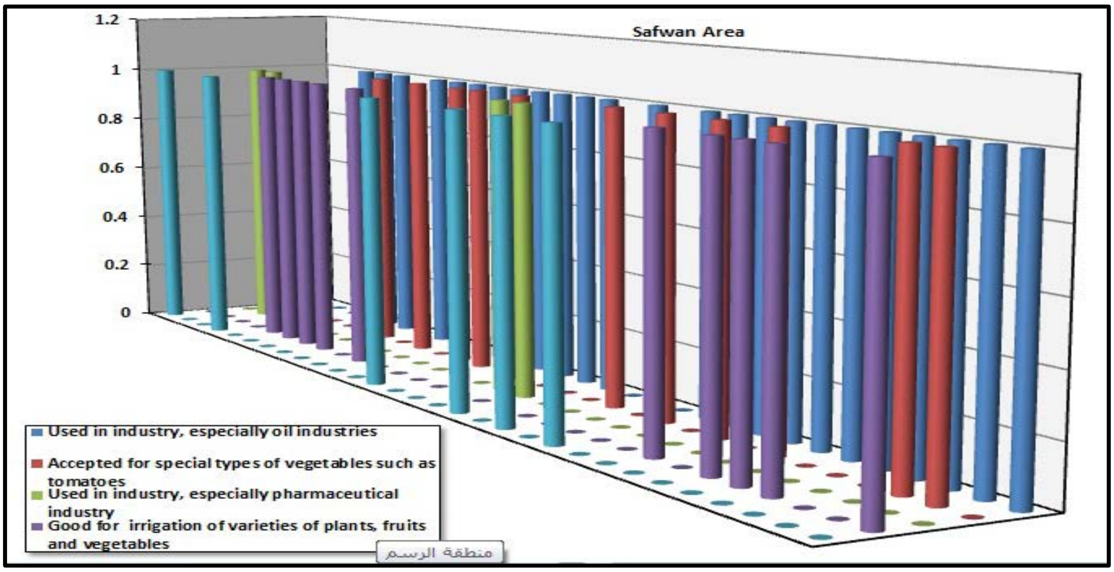


Figure 9: Performance of the artificial neural network proposed for the study area, showing linear compatibility between the measured groundwater quality and their calculated values for the training group, verification and testing

5. Conclusions

The results of the paper indicate the potential of the neural network (EBPANN) in the classification of groundwater quality. This paper has provided the useful of information to how manage groundwater in terms of human, agricultural, industrial and other uses in Al-Zabair and Safwan areas.In addition, the practical side has provided the useful results in the planning and regulation of groundwater use. The percentage of groundwater used in the oil industries (80%, 33.3%) and the percentage of water used in the pharmaceutical industry (13.3%, 6.7%). A good quantity of water for watering varieties of plants and fruits, it is (23.4%, 10%). The percentage of water acceptable to specific types of vegetables such as tomatoes (30%, 3,3%) of the wells studied in Al-Zubayr and Safwan, respectively.



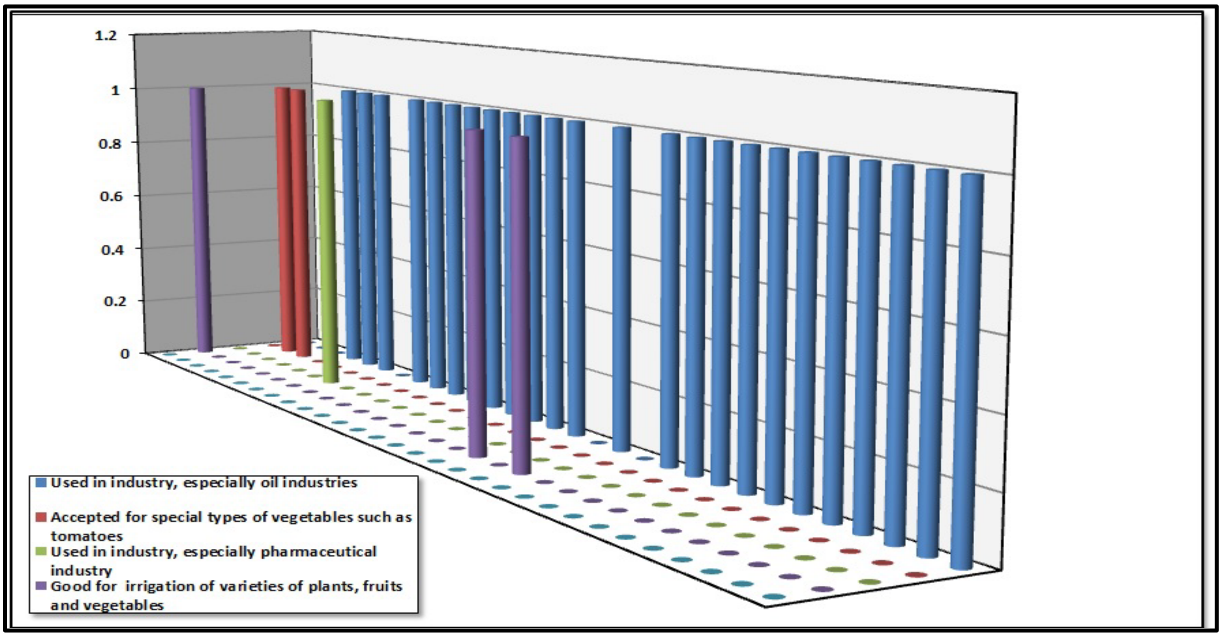


Figure 10 : Classification of the groundwater quality of the study areas (zubayr and safwan area) using the neural network with the back slope of error.

References

[1] Abdalaali, H.H. (2011). "The effect of soil surface mulches, irrigation and nitrogen levels on some soil properties, tomato growth and yield". M.Sc thesis / college of agriculture / university of Basrah / Iraq.

[2] Al meini, A. K. A. (2010). "proposed index of water quality assessment for irrigation". Eng. & Tech. Journal, 28 (22):6557-6571.

[3] Al-Abadi, M.A., 2002 : "Optimum management of model of groundwater resources in Safwan-Zubair area, South of Iraq". Unpub. M.Sc. Thesis, College of Science, Univ. of Basra, 110P.

[4] Al-Aboodi, A.H., 2003 : "A study on Groundwater characteristics in Safwan-Zubair area," Unpub. M.Sc. Thesis, College of Engineering, Uninv. of Basra, 150p.

[5] Atia, A.M., 2000 :" Hydrogeology of Safwan-Zubair area, South of Iraq", Unpub. M.Sc. Thesis, College of Science, Univ. of Basra, 90P. (In Arabic).

[6] Dagar, I. C. (2009)."Opportunities for alternate land uses in salty and water scarcity areas." International Journal of Ecology and Environmental Sciences, 35(1):53-66.

[7] Efe MO (2008), " Novel neuronal activation functions for feed forward neural networks," Neural Process Lett , Vol. 28, pp. 63–79..

[8] Mohammed, M. H. , Mizhir, A. A. and Al-Ba' aj, A. K. (2010)."Determination of nitrate, nitrite and chloride in ground water of some wells/ Basrah, south of Iraq." Scientific Basrah Research, 36(1):59-64.

[9] Majida A. A., Hamid A. A.(2015)"High Accuracy Arabic Handwritten Characters Recognition Using Error Back Propagation Artificial Neural Networks",(IJACSA) International Journal of Advanced Computer Science and Applications,Vol. 6, No. 2,

[10] Semra.,Recep (2018) " Modelling Nitrate Prediction of Groundwater and Surface Water Using Artificial Neural Networks",Vol 2,No. 21:312-325.