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AFFECT OF DROUGHT ON POLLUTION OF LENJ STATION OF ZAYANDEHROOD RIVER BY ARTIFICIAL NEURAL NETWORK (ANN)

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ABSTRACT Iran is one of the most arid countries in the world. In recent years due to planetary climate changes, precipitation reduction has been observed. Rivers provide one the most important domestic water resources as well as agricultural consumptions and are affected by the reduction in rainfall. The amounts of salts in the rivers are increasing and threaten living organism. Therefore prediction of salt quantities in the river based on rainfall reductions is necessary. Three years information of Lenj station was used at Zayandehrood River in this research. The monthly precipitation considered as the input and the river pollutants as output. Modeling with ANN was done and the result showed that discharge, EC & TDS with Root Mean Square Error 9.56 m^3/s, 0.11 dS/m and 84.5 mg/lit respectively depend on rainfall in the case stationed directly.

Keywords: River, Precipitation, Artificial neural network and Modelling.

INTRODUCTION Vast part of our country have dry and semi-dry climate due to locating on the waste belt of the world so it has less precipitation than average amount through the world and this precipitation is rigorously fluctuating during different years. In recent years, due to some reasons, mostly related to global climate changes, fluctuations in different parts of our country have been increased. Increased drought event and floods in different regions of our country all are indicating such fluctuations. Locating more than 90% of our country in a dry zone of the earth resulted in overcoming the drought periods on the wet periods. (Baghersharifi, M. 2006)

Salts amount in the river are going to be increased and averagely in most rivers the concentration of salts have been increased to 2 to 7 times of their initial rate. Today, in most parts of the world, pollution resulted in unusable water resources. Now, water pollution is threatening the health of man and other living organisms. Salinity of fresh water resources due to increased usage of them as well as reduced precipitation all is of main factors for polluting the waters. Drought is of natural disasters with harmful effects on ecological environments (Massoud 2005)

Rivers, as the main resources for supplying the drinking water for cities and villages, play important role in the health of man and environment. But unfortunately, during recent years, by improper exploitation of rivers, man resulted in pollution of the most vital factor through the world. Zayandeh Rood River is originating from Deymeh spring in the ZardKooh Mountains and after adding 1350 million m3 per year to the water of Karoon (by first and second tunnels of Koohrang) and passing the distance of 350 km, it will be ended to the Gave Khooni marsh located in 130 km of Isfahan. Zayandeh Rood river is the main source of Isfahan water resource where after receiving different branches from Zayandeh Rood river, Cham Aseman deviation dam, NekooAbad deviation dam and Abshar deviation dam as well as supplying the water for different usages will be ended to Gave Khooni marsh. Along this route, different usages of water for industrial, agricultural, and drinking purposes are applied and after using some of them, it will be entered to Zayandeh Rood as backwater. Regarding to the statistics of Ministry of Agriculture on 1998, the area of farm lands were about 390,000 ha in area of where, 220,000 ha are locating in the bountry of Zayandeh Rood and more than 4800 million m3 water per year are using for irrigation of these lands and according to the low efficiency of irrigation (averagely 36%) most of it with more pollution, will be returned back to Zayandeh Rood. On the other hand, Gave Khooni marsh and plains surrounding it are suitable habitat for most valuable immigrant and water dwelling birds as well as land birds and rare animals. Therefore, maintaining the quality and quantity of water resources of this important area in Iran can not only influence on the civil, industrial and agricultural development, but also on protection of valuable animal and plant species. (Haeri,M. 2001, Bakhtiyari)

In recent years, there have been presented different models for estimating the quality of water and because water quality depends on various factors, but there are no enough data for estimating the water quality and so artificial neural networks may be used as a proper method to anticipate and estimate the water quality. Most research have been conducted on the artificial neural networks through the world on which one can indicate estimating the precipitation, modeling the ground waters and anticipating the river streams. (ZHAO Ying. 2007).

Artificial neural network is one of the calculating methods, using learning process and processors called neuron tries to present a portray between input space (input layer) and proper space (output layer) acknowledging the intimate relations between data. Cryptic layer(s) process data received from input layer and transfer them to the output layer. Any network can be trained by receiving some examples. Training is a process that finally results in learning. Network learning conducts when relation weights between layers changed such that the difference between anticipated and calculated values is acceptable. Attaining to such conditions, learning is possible. These weights express memory and knowledge. Trained neural network can be applied for providing outputs proportional with new set of data. According to the structure of neural network, its main properties, high processing speed, ability to learn template by template will, ability to generalize knowledge after learning, flexibility against unwilled errors and lack of making a considerable disruption if there is any defect in a part of connections all are due to distributing the network weights (Behroozi, N. 2008)

Sandho and Finch (1995) stressed the ability of artificial neural networks for daily and actually anticipating the salinity in the waters of different areas and ability for estimating the concentration of cations and anions as well as the value of EC and TDC in such fields (Maier, H.R. and G.C. Dandy 1996, Erenturk, 2007).

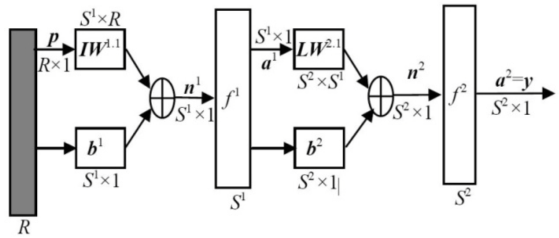
In a study about anticipating the salinity of Marry river using artificial neural networks, Myer and Dendi (2000) concluded that artificial neural networks (ANNs) model is an accurate tools for estimating the quality loss in this river with the difference between observed and stimulated value was between 46 to 53 μmouse per cm. they proposed to compare this model with other physical or mathematical models.

When anticipating the pollution (DO, BOD) of Youkayo, China, Zhoving (2007) indicated that AANs can be an easy and suitable method with fewer errors.

This study aims to examine the effects of precipitation on the quality of water of Zayandeh Rood in Lenj station and anticipating it using artificial neural network.

Materials and Methods In this study, multilayer perceptron (MLP) was used. This network includes an input layer, one or several cryptic layer(s) and an output layer. Back propagation (BP) algorithm was used for training this network. During training the MLP networks by BP learning algorithm, calculations were initially conducted from network's input to its output. Then values of calculated errors distributed to previous layers. Steps of training by this algorithm include: (a) dedicating accidental weight matrix to each joint (b) selecting the input and output vector proportional with it (c) calculating the neuron output in each layer and consequently calculation of neurons output in the output layer (d) updating the weights by method of distributing the network error to previous layers and mentioned error resulted from difference between actual and calculated output (e) evaluating the performance of trained network by using some defined indices like MSE (mean square equations) and finally returning to the end of training.

Model used in this article is BP artificial neural network with a cryptic layer. Figure (!) indicates the structure of a ANN with a cryptic layer; where, R: input layer, S1: cryptic layer, S2: output layer, 1.IW1: layer weight in the input layer, 1.LW2: weight in the cryptic layer for output layer, b1 and b2: validity threshold in cryptic and output layer respectively, and f1 and f2 are functions for conducting the neurons in cryptic and output layers respectively.(Massoud M., Scrimshaw M. D. and J. N. Lester. 2005)



Figor1: Figure (1) - neural network with a hidden layer

Data are used related to the Lenj hydrology station for three years (2003-2005). Figure (2) indicates the situation of this station. This station is located on 51° 33' 48.96" of geographical longitudinal and 32° 23' 31.92" of geographical transverse in 32km of Isfahan.

Figure2. Zayendehrood basin in IRAN

This information include: daily precipitation, Discharge, total solutes, electric conductivity, soil reaction, carbonate, bicarbonate, chlorine, calcium sulfate, magnesium, sodium, potassium, and sodium absorption ration. Daily data changed to monthly ones and precipitation has been considered as an influencing factor on other parameters. Monthly precipitation as input and other parameters as output entered to the system and finally 448 figures entered to artificial neural network and network was modeled and trained and then correlation index and SME were calculated (equations 1 and 2).

$$E_t = \frac{1}{2}\sum_{j=1}^{q}(y_j(t) - d_j(t))^2 \qquad (1)$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{j=1}^{q}(y_j(t) - d_j(t))^2} \qquad (2)$$

Where:

E(t): error related to time t, RMSE: mean square equation of error; q: number of neurons in the output layer; j(s2): number of neurons in yj(t); yj(t): actual values of output layer in time t; dj(t): values estimated by network in the output layer and n: number of inputs and outputs.

To design the ANN, MATLAB software was used. For training the network, precipitation of 32 month as input and other factors, totally 416 (13× 32) as output entered to the system. Number of layers and different neurons entered to the network, SME, correlation index were calculated for each network, such that choosing two layers and 5 neurons resulted in highest correlation index and lowest error.

Results and Discussion Using artificial neural network and data of daily precipitation in this study, Discharge values, total of solutes, electric conductivity, soil reaction, carbonate, bicarbonate, chlorine, calcium sulfate, magnesium, sodium, potassium, and sodium absorption ration were calculated in the Lenj station and following results were obtained.

Choosing 2 layers and 5 neurons with correlation coefficient of 0.99, networks could be trained (figure 3). According to figure (4), two factors of TDS and EC, actual values are properly correlated with calculated values. For Discharge, although they indicate good trends, but it has gross errors in some months (RMES equals with 9 m3/s) and its main reason is due to controlled Discharge of river water by Zayandeh Rood. In months with higher precipitation, dam will be closed for watering with no Discharge and vice versa in dry months, dam was opened with higher Discharge.

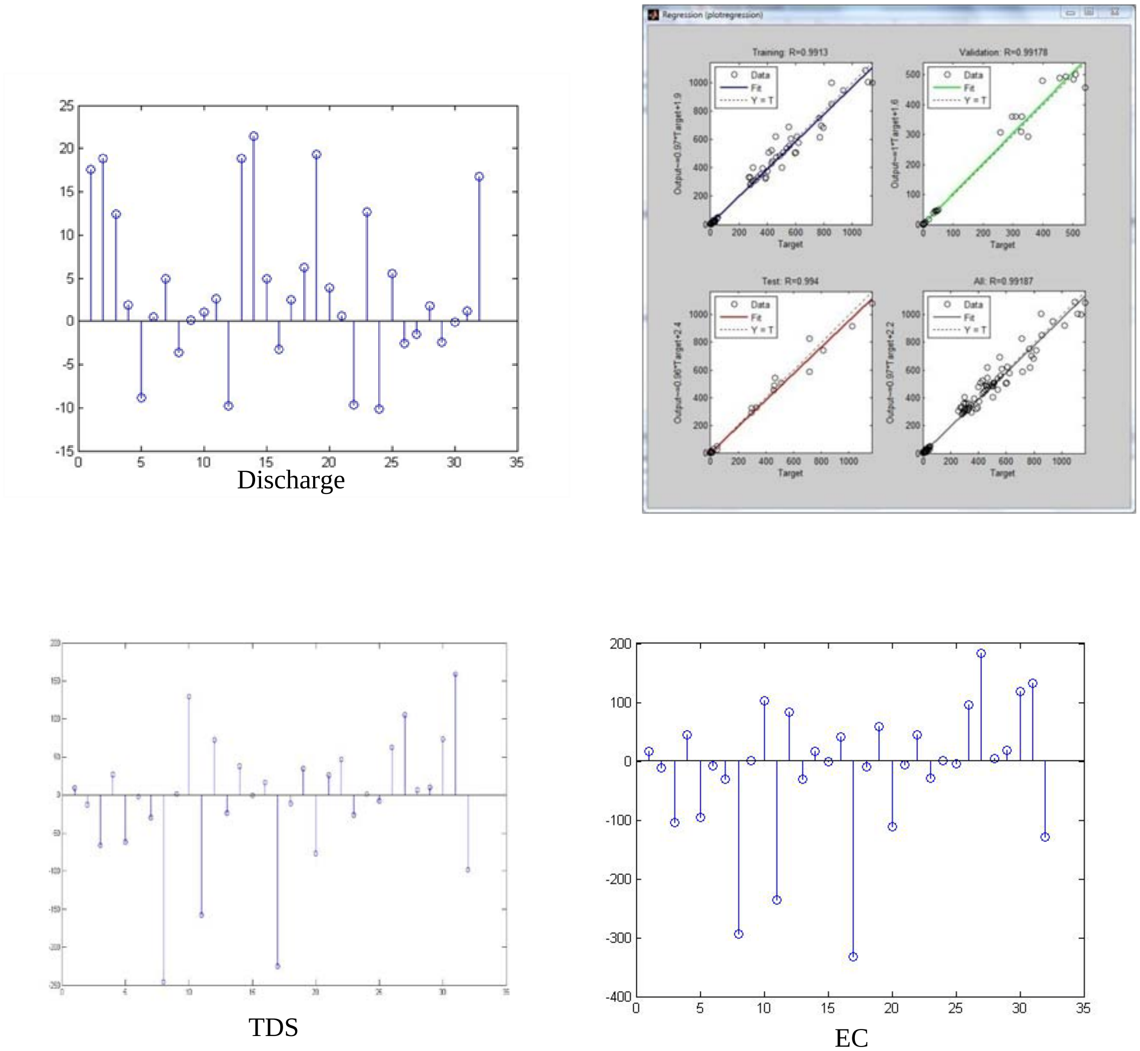


Figure4. Error for Discharge, EC&TDS for 10 stations

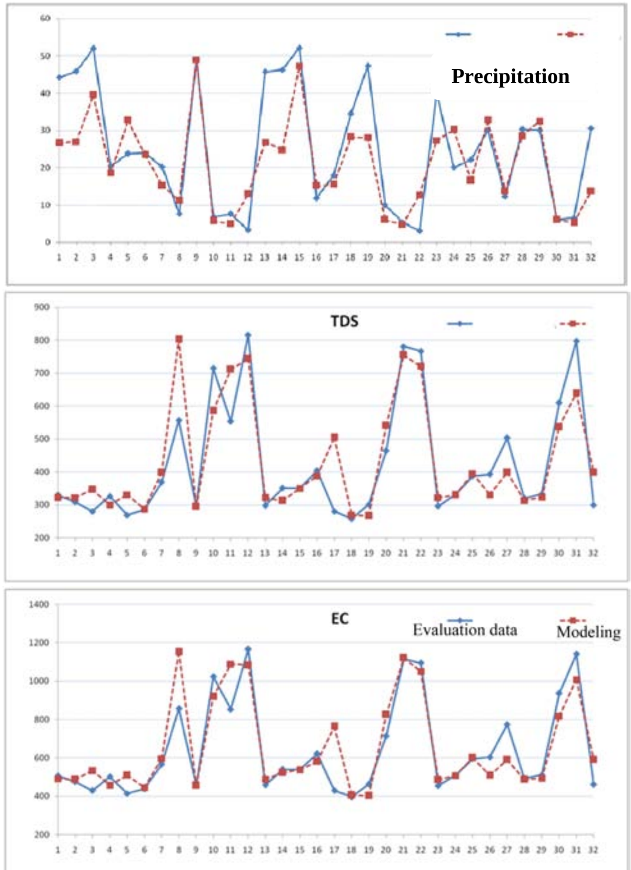


Figure5. Difference whit real data and calculated data

To anticipate the influence of reduced precipitation on different values of output parameters, there were anticipated three precipitations (2000, 200 and 100 mm) as input and other parameters as output (table 1).

Table 1. Data assessment with ANN for different irrigation water

(mm) rainfall	100	200	2000
Discharge $\frac{m^3}{s}$	4.47	4.64	10.21
TDS	812.86	782.01	268.54
EC	1155.83	1136.63	1091.28
pH	8.32	8.37	7.21
CO3	0.032	0.09	0.22
HCO3	2.73	2.14	3.19
Cl	3.75	3.68	0.65
SO4	0.11	0.15	4.89
Ca	4.90	4.90	2.20
Mg	2.10	2.12	2.70
Na	4.99	4.98	1.12
K	0.005	0.001	0.14
SAR	0.01	0.02	0.59

CONCLUSION Using artificial neural network, creating two layers and five neurons, the influence of precipitation was simulated on parameters (Discharge values, total of solutes, electric conductivity, soil reaction, carbonate, bicarbonate, chlorine, calcium sulfate, magnesium, sodium, potassium, and sodium absorption ration) with correlation coefficient of 0.99. Results indicate that: In the studied station, some factors may be directly influenced by precipitation and by increasing the precipitation, it resulted in increased Discharge and reduced TDS, EC and Na and other parameters may not be directly influenced by precipitation. When monthly precipitation reduced to 100mm, we expect that Discharge in Lenj station reduces to 4.5 m3/s. it must be mentioned that the amount of pollutions in the river depends on many factors such as land use, backwaters (industrial, agricultural and civil),… and must be considered in the calculations.

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