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Comparing the Performance of Artificial Intelligence Models in Estimating Water Quality Parameters in Periods of Low and High Water Flow

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Introduction: A total dissolved solid (TDS) is an important indicator for water quality assesment. Since the composition of mineral salts and discharge affects the TDS of water, it is important to understand the relationships of mineral salts composition with TDS.

Materials and Methods: In this study, methods of artificial neural networks with five different training algorithm,Levenberg-Marquardt (LM), Scaled Conjugate Gradient (SCG), Fletcher Conjugate Gradient (CGF), One Step Secant (OSS) and Gradient descent with adaptive learning rate backpropagation(GDA)algorithm and adaptive Neurofuzzy inference system based on Subtractive Clustering were used to model water quality properties of Zarrineh River Basin, to be developed in total dissolved solids prediction. ANN and ANFIS program code were written in MATLAB language. Here, the ANN with one hidden layer was used and the hidden nodes' number was determined using trial and error. Different activation functions (logarithm sigmoid, tangent sigmoid and linear) were tried for the hidden and output nodes. Therefore, water quality data from seven hydrometer stationswere used during the statistical period of 18years (1993-2010).In this research, the study period was divided into two periods of dry and wet flow, and then in a preliminary statistical analysis, the main parameters affecting the estimation of the TDS are determined and isused for modeling. 75% of data are used for remaining and 25% of the data are used for evaluation of the model, randomly. In this paper, three statistical evaluation criteria, correlation coefficient (R), the root mean square error (RMSE) and mean absolute error (MAE) were used to assess models' performances.

Results and Discussion: By applying correlation coefficients method between the parameters of water quality and discharge with total dissolved solid in two periods, wet and dry periods, the significant (at 95% level) variables entered into the model were Q, HCO_3., Cl, So4, Ca, Na and Mg. The optimal ANN (LM) architecture used in this study consists of an input layer with seven inputs, one hidden and output layer with two and five neurons for dry and wet periods, respectively. Similar ANN(LM), ANFIS-SC model had the best performance. It is clear that the ANFIS with 0/72 and 0/58 radii value has the highest R and the lowest RMSE for dry and wet periods, respectively. Comparing the ANFIS-SC estimations with the measured data for the test stage demonstrates a high generalization capacity of the model, with relatively low error and high correlation. From the scatter plots it is obviously seen that the ANFIS-SC predictions are closer to the corresponding measured TDS than other models in two periods. As seen from the best straight line equations (assume the equation as y=ax) in the scatter plots that the coefficient for ANFIS-SC is closer to 1 than other models. In addition ANFIS-SC performancedwith the correlation coefficients in dry and wet periods, respectively 0.975 , 0.969 and with Root-mean-square errors, respectively 34.41 , 23.85 in order to predict dissolved solids (TDS) in the rivers of Zarrineh River Basin. The obtained results showed the efficiency of the applied models in simulating the nonlinear behavior of TDS variations in terms of performance indices. The results are also tested by using t test for verifying the robustness of the models at 99% significance level .Comparison results indicated that the poorest model in TDS simulation was ANN-GDAin dry and wet periods, especially in test period. The observed relationship between residuals and model computed TDS values shows complete independence and random distribution. It is further supported by the respective correlations for ANFIS-SC models (R^2 = 0.0012 for dry period and R^2 = 0.0214 for wet period) which are negligible small. Plots of the residuals versus model computed values can be more informative regarding model fitting to a data set. If the residuals appear to behave randomly it suggests that the model fits the data well. On the other hand, if non- random distribution is evident in the residuals, the model does not fit the data adequately. On the base of these results, we propose ANFIS-SC and ANN (LM) methods as effective tools for the computation of total dissolved solids in river water, respectively.

Conclusion: It can be concluded that the ANN with Levenberg-Marquardt training algorithm and ANFIS-SC models can be considered as promising tools for forecasting TDS values, based on water quality parameters. With attention to the aim of current research that is presenting the feasibility of artificial intelligence techniques

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for modeling TDS values, it is notable that the results presented in this paper are for research purpose and applying the abstained results for real-world needs some complicated steps and building artificial intelligences methods, based on complete data and parameters maybe affected the TDS values.

Keywords: Adaptive neuro fuzzy inference system, Artificial neural network, Dissolved solids, Zarrineh River