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Estimation of Suspended Sediment Load Based on Physiographic Parameters of the Watershed

Mehdi Hayatzadeh[1], Sahar Amini[2], Ali Fathzadeh[3*], Maryam Asadi[4]

1-Assistant Professor of Watershed Management Department, Ardakan University, Ardakan. Iran
2-Master student of watershed management Department, Ardakan University, Ardakan.
3-Associate Professor of Watershed Management, Ardakan University, Ardakan, Iran.
4-Ph.D in Watershed Management, University of Tehran, Tehran, Iran

1- Introduction

Suspended sediment load is one of the most important river elements that affects water quality, and has an effective role in managing hydraulic structures of water resources. Therefore, its estimation can be a great help in increasing the efficiency of water resources and improving the performance of hydraulic structures. In recent years, scientists have been able to calculate the amount of suspended load using artificial intelligence methods as a new tool in the field of erosion and sediment transportation. In addition to the importance of applying appropriate methods for estimating suspended sediment loads, the use of effective parameters in sedimentation is also very important. Kumar et al. (2016) used different methods of hydrological and data mining to estimate the suspended load of the Copel River. Comparison of different methods showed that support vector machine and artificial neural network methods were more accurate than hydrologic methods and decision tree algorithms. In addition to the importance of using appropriate methods for estimating suspended sediment load, the use of effective parameters in sedimentation is also of utmost importance. Therefore, in this study, the effect of physiographic parameters in combination with data mining models has been investigated to estimate suspended sediment load.

2-Methodology

- Study Areas

The studied area included 30 watersheds located in Lorestan province from Iran (Figure 1).

* Corresponding Author: **E-mail:**fat@ardkan.ac.ir

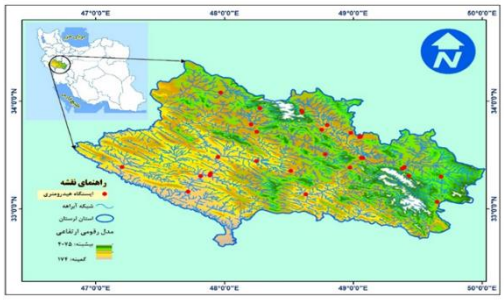

Figure (1). Location of Study Stations in Lorestan province and in Iran

- Data processing

After determining the hydrometric stations with suitable statistical period and data, the minima, maxima and mean values of flow discharge and sediment data were also calculated. Then, the physiographic parameters were calculated using ArcGIS software through related relationships. In this study, the effect of various physiographic indices on sediment estimation was evaluated. Moreover, different data mining models such as artificial neural network, evolutionary propulsion vector, decision tree M5, Gaussian process, and linear regression were applied.

Artificial neural networks are a type of statistical model. In case the relationship between input and output of the physical system be complex and nonlinear, this relationship can be detected with a network of interconnected nodes that are all interconnected. Evolutionary Support Vector Machine (**ESVM)** uses an evolutionary strategy to optimize the issue. In fact, it provides an evolutionary algorithm to solve the dual optimization problem. Implementation of this algorithm in many data sets is faster and easier than simple vector machine.
Decision tree learning is a method for estimating discrete-value functions that are resistant to complex data and can be used to learn the terms of different branches.
A Gaussian process is a stochastic process, which consists of random values at any point in space or time domain so that each of the variables are normally distributed.
Linear regression is used to model the value of a dependent quantitative variable based on its linear relationship with one or more independent variables.

- Evaluation Model

In order to evaluate the models and compare their results, the Root Mean Squared Error (RMSE), Correlation Coefficient (r), Normalized Mean Absolute Error (NMAE), and Absolute Error (AE) were served.

Weighting parameters

All input parameters of the model do not have the same effect in prediction. Some parameters are more correlated with the output of the model and have a greater impact on the predictions. In this study, in order to determine the effective index in estimating the suspended sediment load, the weights of the indices were performed using the support vector machine algorithm.

3- Results and Discussion

Initially, the models were applied to a data set that only used discharge as an effective parameter in suspended sediment estimation of the model input. The results showed that the evolutionary support vector model with RMSE = 6.763 and r = 0.994 was the best model in prediction (Table 1).

Table (1): Results of evaluation criteria applied to the model based on the input data set with discharge

Model	ANN	ESVM	M5	GP	LR
RMSE	15.148	**6.736**	15.15	8.551	19.362
r	0.969	**0.994**	0.954	0.999	0.924
NMAE	17.47	**5.97**	8.04	8.26	15.73
AE	11.292	**3.925**	7.961	7.46	14.706

The distribution of predicted and observed values has been presented in Figure 2.

Then, in order to investigate the effect of physiographic parameters on prediction accuracy, these parameters were used as inputs. The results showed that in this data set s, the prediction accuracy, increased in all models. Therefore, the results of this data set showed that Evolutionary Support Vector Machine model, with a RMSE= 3.04 and r= 0.999, was the best model showing better results. The results of all models have been presented in Table 2. Observed and predicted values of the suspended sediment load of this data set have been also presented in Figure 3.

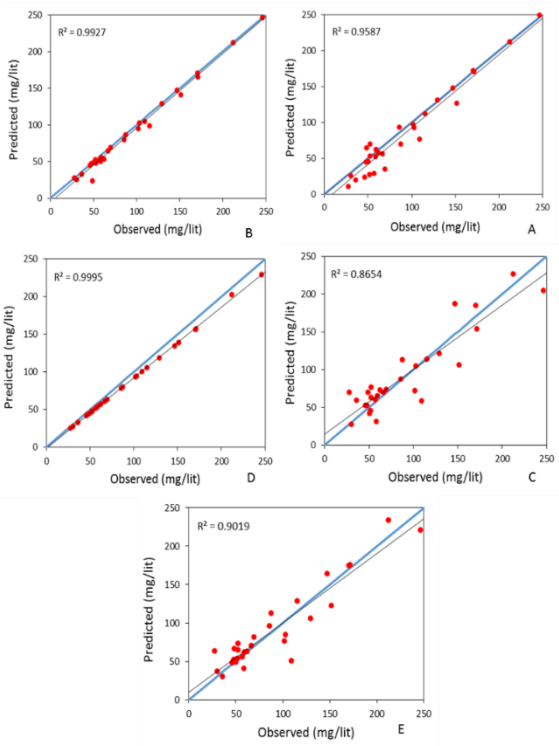

Figure (2). Distribution diagram of observed and predicted amounts of suspended sediment load by models A: Artificial Neural Network, B: Evolutionary Support Vector Machine, C: Decision Tree M5, D: Gaussian Process, e: Regression, Regardless of Physiographic Parameters

Table (2): Results of the evaluation criteria applied to the model based on the data set with parameter input

Model	ANN	ESVM	M5	GP	LR
RMSE	4.935	3.04	11.522	4.097	16.165
r	0.998	0.999	0.982	0.998	0.964
NMAE	0.081	0.035	0.156	0.024	0.253
AE	4.012	1.723	7.782	1.384	12.567

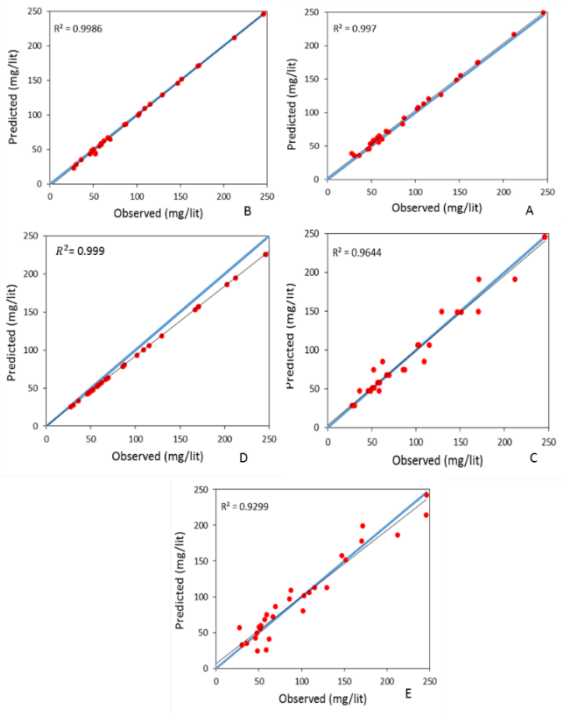

Figure 3. Distribution diagram of observed and predicted amounts of suspended sediment load by models A: Artificial Neural Network, B: Evolutionary Support Vector Machine, C: Decision Tree M5, D: Gaussian Process, e: Regression, Considering Physiographic Parameters.

4- Conclusions

The use of physiographic parameters increased the accuracy of the model in prediction. Since discharge was used as the only input for the models, the results were less accurate. Using physiographic indices, the accuracy of the models was improved so that in the artificial neural network model, the amount of squares of error reduced from 15.148 to 4.935. This trend was visible in all used models. The results of model evaluation also showed that the evolutionary support vector machine model had the best performance in predictions.

Keywords: Suspended load, Physiographic parameters, Data mining, Evolutionary vector machine, Computational intelligence, Lorestan Province

5-References

Kumar, D., A. Pandey, N. Sharma and W. Flugel. (2016). *Daily suspended sediment simulation using machine learning approach*. Catena, 138: 77-90.