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Comparison of Sediment Rating Curve and Artificial Neural Network in Simulation of Suspended Sediment Load

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Abstract : Sediment, which comprises of solid particles of mineral and organic material are transported by water. In river systems, the amount of sediment transported is controlled by both the transport capacity of the flow and the supply of sediment. The transport of sediment in rivers is important with respect to pollution, channel navigability, reservoir ageing, hydroelectric equipment longevity, fish habitat, river aesthetics and scientific interests. The sediment load transported in a river is a very complex hydrological phenomenon. Hence, sediment transport has attracted the attention of engineers from various aspects, and different methods have been used for its estimation. So, several experimental equations have been submitted by experts. Though the results of these methods have considerable differences with each other and with experimental observations, because the sediment measures have some limits, these equations can be used in estimating sediment load. In this present study, two black box models namely, an SRC (Sediment Rating Curve) and ANN (Artificial Neural Network) are used in the simulation of the suspended sediment load. The study is carried out for Seonath subbasin. Seonath is the biggest tributary of Mahanadi river, and it carries a vast amount of sediment. The data is collected for Jondhra hydrological observation station from India-WRIS (Water Resources Information System) and IMD (Indian Meteorological Department). These data include the discharge, sediment concentration and rainfall for 10 years. In this study, sediment load is estimated from the input parameters (discharge, rainfall, and past sediment) in various combination of simulations. A sediment rating curve used the water discharge to estimate the sediment concentration. This estimated sediment concentration is converted to sediment load. Likewise, for the application of these data in ANN, they are normalised first and then fed in various combinations to yield the sediment load. RMSE (root mean square error) and R^2 (coefficient of determination) between the observed load and the estimated load are used as evaluating criteria. For an ideal model, RMSE is zero and R^2 is 1. However, as the models used in this study are black box models, they don't carry the exact representation of the factors which causes sedimentation. Hence, a model which gives the lowest RMSE and highest R^2 is the best model in this study. The lowest values of RMSE (based on normalised data) for sediment rating curve, feed forward back propagation, cascade forward back propagation and neural network fitting are 0.043425, 0.00679781, 0.0050089 and 0.0043727 respectively. The corresponding values of R^2 are 0.8258, 0.9941, 0.9968 and 0.9976. This implies that a neural network fitting model is superior to the other models used in this study. However, a drawback of neural network fitting is that it produces few negative estimates, which is not at all tolerable in the field of estimation of sediment load, and hence this model can't be crowned as the best model among others, based on this study. A cascade forward back propagation produces results much closer to a neural network model and hence this model is the best model based on the present study.

Keywords : artificial neural network, Root mean squared error, sediment, sediment rating curve
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