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Groundwater Pollution Source Identification using Linked ANN-Optimization Model

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Groundwater is the principal source of drinking water in several parts of the world. Contamination of groundwater has become a serious health and environmental problem today. Human activities including industrial and agricultural activities are generally responsible for this contamination. Identification of groundwater pollution source is a major step in groundwater pollution remediation. Complete knowledge of pollution source in terms of its source characteristics is essential to adopt an effective remediation strategy. Groundwater pollution source is said to be identified completely when the source characteristics – location, strength and release period – are known. Identification of unknown groundwater pollution source is an ill-posed inverse problem. It becomes more difficult for real field conditions, when the lag time between the first reading at observation well and the time at which the source becomes active is not known.

We developed a linked ANN-Optimization model for complete identification of an unknown groundwater pollution source. The model comprises two parts- an optimization model and an ANN model. Decision variables of linked ANN-Optimization model contain source location and release period of pollution source. An objective function is formulated using the spatial and temporal data of observed and simulated concentrations, and then minimized to identify the pollution source parameters. In the formulation of the objective function, we require the lag time which is not known. An ANN model with one hidden layer is trained using Levenberg-Marquardt algorithm to find the lag time. Different combinations of source locations and release periods are used as inputs and lag time is obtained as the output.

Performance of the proposed model is evaluated for two and three dimensional case with error-free and erroneous data. Erroneous data was generated by adding uniformly distributed random error (error level 0-10%) to the analytically computed concentration values. The main advantage of the proposed model is that it requires only upper half of the breakthrough curve and is capable of predicting source parameters when the lag time is not known. Linking of ANN model with proposed optimization model reduces the dimensionality of the decision variables of the optimization model by one and hence complexity of optimization model is reduced. The results show that our proposed linked ANN-Optimization model is able to predict the source parameters for the error-free data accurately. The proposed model was run several times to obtain the mean, standard deviation and interval estimate of the predicted parameters for observations with random measurement errors. It was observed that mean values as predicted by the model were quite close to the exact values. An increasing trend was observed in the standard deviation of the predicted values with increasing level of measurement error. The model appears to be robust and may be efficiently utilized to solve the inverse pollution source identification problem.