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Estimating groundwater pollution source location using neural networks presented with partial and noisy data

Jitendra Kumar[1]**,** Ashu Jain[2], and Rajesh Srivastava[2]

[1]M. Tech. Student, Indian Institute of Technology Kanpur, India; (jitendra@iitk.ac.in)

[2]Associate Professor, Indian Institute of Technology Kanpur, India; (ashujain@iitk.ac.in)

[2]Associate Professor, Indian Institute of Technology Kanpur, India; (rajeshs@iitk.ac.in)

The groundwater aquifers have been subjected to a high risk of being contaminated in recent years by harmful chemicals due to many reasons e.g. industrialization, increased use of pesticides and number of underground petrol storage tanks. Once an aquifer is contaminated, it may take a long time and considerable expenditure to restore it to an acceptable state. It is important to identify the pollution sources in order to take punitive or remedial measures. Identifying the sources causing pollution in the aquifers has been the subject of research for many decades. Traditionally, hydrologists have relied on the conceptual methods for the identification of groundwater pollution sources. Artificial neural networks (ANNs) have been proposed as efficient tools for modeling and forecasting of the complex engineering systems. Recently, some researchers have attempted to use ANNs for the identification of groundwater pollution sources. The measured concentrations of the contaminant at an observation well (called a breakthrough curve) can be erroneous due to many reasons. The ANNs posses the ability to be efficient when presented with partial and noisy information and may be useful in groundwater pollution source identification with partial data and data containing measurement and other type of errors.

This paper presents the results of a study aimed at identifying the location of a pollution source from an observation well using ANNs when presented with partial data with increasing level of noise. The ANN models were developed using simulated data generated for conservative pollutant transport through a homogeneous aquifer. The feed-forward multi-layer perceptron (MLP) type neural networks trained using the back-propagation training algorithm in a stepwise mode, were employed in this study.

The ANN model consisted of an input layer, one hidden layer, and an output layer. In order to test the ability of ANNs when presented with partial data, the observed breakthrough curve was divided into ten equal parts and the concentration values at the eleven end-points and the associated times were presented to the input layer of the ANN. With the output neuron in the output layer representing the distance of the pollution source from the observation well, the ANN structure of 22-N-1 was investigated. Further, the input data were perturbed by adding noise to assess the ANNs' ability in estimating the distance of the pollution source with increasing level of noise. The results obtained in this study indicate that the performance of the ANN model developed on partial and noisy data in terms of certain standard statistical parameters e.g. correlation coefficient, Nash-Sutcliffe efficiency, average absolute relative error, etc. was comparable to the ANN models developed using complete and accurate data. This study is able to demonstrate that the ANNs offer an exciting alternative to the problem of groundwater pollution source identification with partial and noisy data.