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Assessment of neural network technique for estimating fecal coliform based on hydrologic and climatic data

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The United States Environmental Protection Agency (USEPA)'s Water Quality Planning and Management Regulations require states to develop total maximum daily loads (TMDLs) for their water bodies that are not meeting designated uses under technology based controls for pollution. There are enormous numbers of parameters (physical, chemical, and biological) that can be used as the water quality indicator for various purposes. It is not possible to develop extensive monitoring networks to measure each and every water quality indicator at the required spatial and temporal scales due to several constraints e.g. exorbitant costs involved, non-availability of manpower, and problems in maintenance of the equipment, etc. Mathematical models can facilitate the estimation of a water quality indicator parameter based on the measurements of some hydrologic and climatic data, which are easily available. Traditionally, conventional techniques of regression analysis have been employed for such purposes. In recent years, artificial neural networks (ANNs) have been proposed as efficient tools for modeling and forecasting of various physical systems. The ANNs have been applied to a very wide variety of areas and are purported as the most efficient tool for estimation and forecasting. Some recent literatures have suggested that the simple ANN models may not be adequate in modeling the extremely complicated physical systems.

This paper presents a case study of the use of ANNs for estimating the fecal coliform at a location in a river based on certain hydrological and climatic data. The data were obtained from the North Fork Kentucky River at Jackson, Kentucky, USA. The data employed include fecal coliform (counts per 100 ml), streamflow (m^3/s), water

temperature (^{o}C), and air temperature (^{o}C). The feed-forward multi-layer perceptron (MLP) type neural networks trained using the back-propagation training algorithm in batch mode, were employed in this study. The ANN model consisted of an input layer, one hidden layer, and an output layer. The input layer consisted of the indicator water quality parameters and the output layer consisted of a single neuron representing fecal coliform to be estimated. The number of hidden neurons was determined through a trial and error procedure. The performances of all the models investigated in this study were evaluated using certain standard statistical measures e.g. correlation coefficient, Nash-Sutcliffe efficiency, average absolute relative error, etc. The results obtained in this study indicate that the simple ANN models are not adequate in capturing the highly complex, non-linear, and dynamic relationships inherent in the input and output data considered in this study. The study presented demonstrates that special efforts are needed to obtain adequate model performance in estimating fecal coliform based on hydrologic and climatic parameters.