

AN ABSTRACT OF A DISSERTATION

MODELING WATER TREATMENT PROCESSES VIA NEURAL NETWORKS AND GENETIC ALGORITHMS

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Attempts to capture the complex physical and chemical relationships of water treatment processes by fitting pilot-scale study data to a mathematical formula have generally been unsuccessful. Water utilities, therefore, need a better modeling technique to model these processes. Neural nets (NNs) trained with a backpropagation (BP) algorithm have been widely used for this purpose due to several reasons: (1) they have been found in practice to generalize well, and (2) the BP algorithm can often find a good set of weights in a reasonable amount of time. Since the BP algorithm is based on calculating the gradient of error with respect to weights and differentiability, it is a very good algorithm for exploring local solutions, but, for the same reason, it can also cause failures in training NN because it can become trapped in local minima (Ham et al., 2000; Haykin, 1999). This problem may be overcome by applying the genetic algorithm (GA) to NN weight optimization. GA is a derivative-free stochastic optimization method based on the features of natural selection and biological evolution. GA is able to explore a large and complex search space and has the potential to produce a global solution, thereby avoiding local minima. In a GA based training NN (GANN), weights are updated according to the GA operators, such as ranking (fitness values), selection, and recombination (crossover and mutation).

The objectives of this study were twofold. The first objective was to apply and study the effectiveness of two different NN training algorithms (BP and GA) as NN predictive models. This comparison was made by using each algorithm to predict the coagulant dosage for two water treatment plants (WTPs) in middle Tennessee and for predicting the formation of disinfection byproducts (DBP, i.e., THM4 and HAA5) using the data from the USEPA's Information Collection Rule (ICR). The second objective was to document the NN modeling procedures used in this project so that they could be used as a basis for developing site-specific NN models for the water industry. The results illustrated that GANN can avoid local minima and effectively produce a global solution. The BPNN produced better correlation coefficients (r) for both the coagulant dosage and DBP models once they successfully avoided the local minima. The average r -value was approximately 0.89 for both WTPs, and 0.94 and 0.88 for the THM4 and HAA5 models, respectively. The lower r -value (0.88) from the HAA5 model was found mainly due to the uncertainty errors that were in the HAA5 testing data subset. Overall, Both BPNN and GANN successfully captured the complex nonlinear relationships involved in predicting coagulant dosages and DBP formation.