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Estimating spatial distribution of water quality in landfill site

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Abstract

In this study, the performance of artificial neural network (ANN) models for estimating spatial distribution of water quality was evaluated using electric conductivity (EC) values in landfill site. For the ANN model development, feedforward neural networks and backpropagation algorithm with gradient descent method were used. In Test 1, the interpolation ability of the ANN model was evaluated. Results of the ANN model were more precise than those of the Kriging model. In Test 2, spatial distributions of EC values were predicted using precipitation data. Results seemed to be reasonable, however, they showed a limitation of ANN models in extrapolations.

key words : spatial distribution, electric conductivity, artificial neural network, Kriging

1. Introduction

Estimating spatial distribution of water quality using limited observation data is often required for designing water resource managements or remediations. Kriging techniques have been most widely used for this purpose. Recently, artificial neural network (ANN) techniques have been applied to estimating spatial distribution of aquifer properties, such as hydraulic conductivity (Basheer et al., 1996; Mukhopadhyay, 1999). In this study, we evaluated the performance of ANN models for estimating spatial distribution of the ground water quality at a landfill site. Specific electric conductivity (EC) values were used as an index of the water quality.

2. Methods and Materials

The study site is an unsanitary landfill which is located in Wonju. There are eight observation wells outside the barrier wall of the landfill (Figure 1). The field measurements of ground water level and quality, including EC, have been conducted since February, 2005. EC values of nine times sampling events conducted in 2005 consisted the data set for this study. For the ANN model development, we used feedforward neural networks and the backpropagation algorithm with gradient descent method.

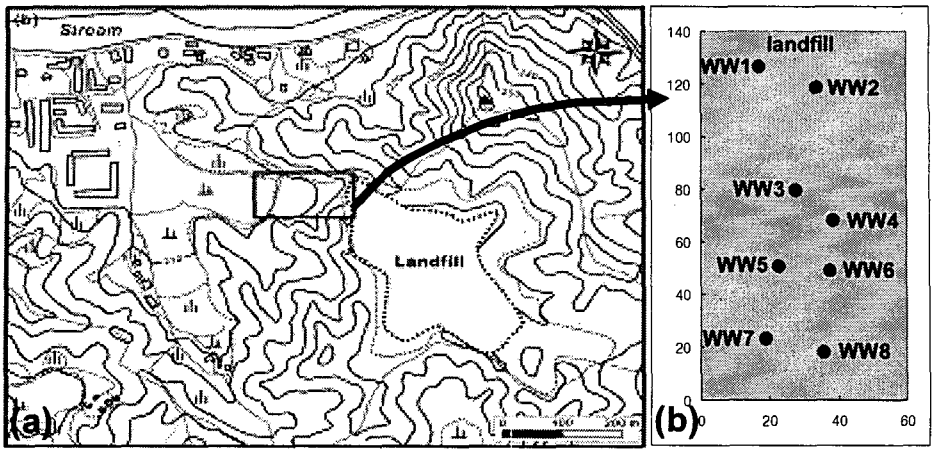

Figure 1. Location of the study site (a), and model domain (b)

Two tests were designed for this study. In Test 1, the interpolation ability of the ANN model was evaluated. Inputs were coordinates of the well location, and outputs were EC values. Results were compared with those of the Kriging model. In Test 2, we developed ANN models for forecasting the spatial distribution of EC values considering input variables of location and precipitation. Figure 2 shows structures of the ANN models.

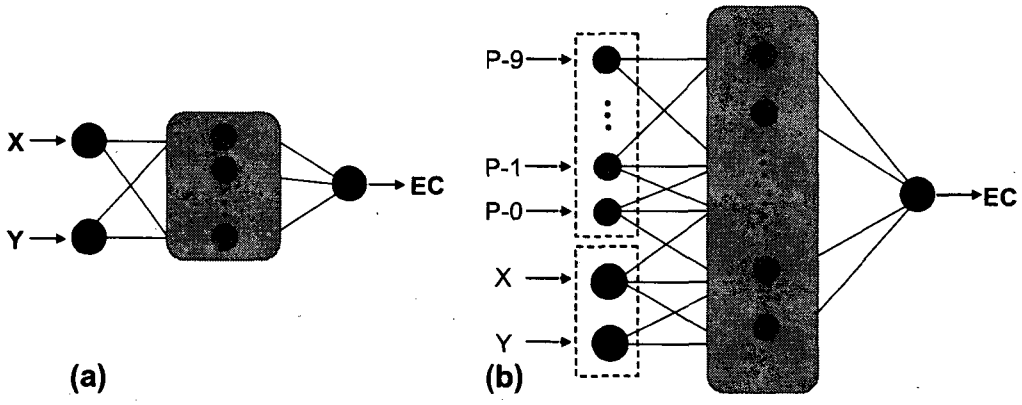

Figure 2. ANN model structures for Test 1 (a), and Test 2(b)

3. Results and Discussions

In Test 1, for a simple test, EC values of two times of sampling events, February and August, were considered, and the EC value of one observation well (WW5) was interpolated. The result of the ANN model and Kriging model is presented in Figure 3. The interpolation errors are -14.7(%) and -1.7(%) for the ANN model, 18.6% and 47.4% for the Kriging model. The ANN model slightly underestimated interpolation values, however, estimated more precisely than the Kriging model.

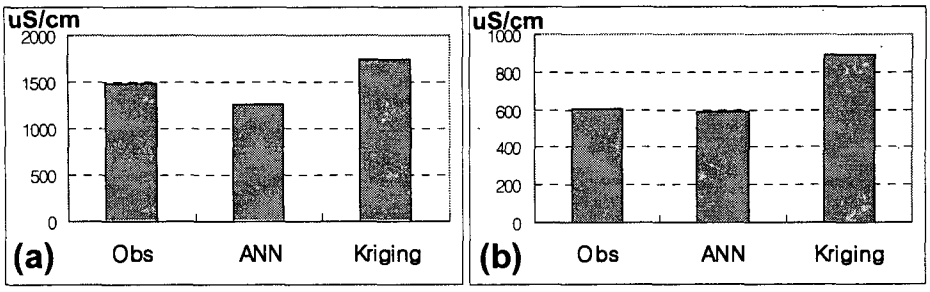

Figure 3. The result of Test 1; (a) 2005/02/04, (b) 2005/08/02

Figure 4 shows the result of 5-fold cross validation in Test 2. The root mean square error was 454.6 (uS/cm) and correlation coefficient value was 0.86. In case of forecasting EC values in August, when precipitation events are concentrated, the error was highly increased. This shows a limitation of ANN models in forecasting beyond the range of model training.

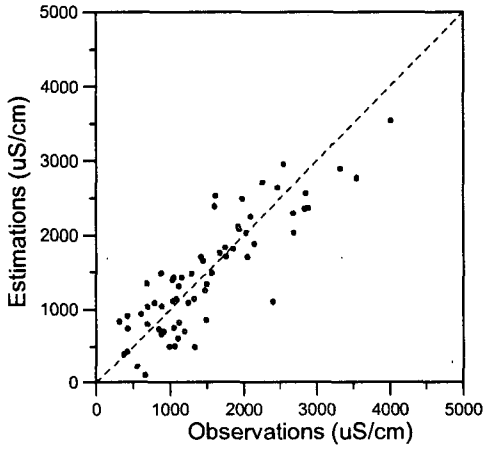

Figure 4. The result of Test 2

References

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