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Daily Water Quality Forecast of the South-to-North Water Diversion Project of China Using the BP Network Optimized by the Cuckoo Search Algorithm

Xizhi Nong, Dongguo Shao, Yi Xiao, Hua Zhong, and Yanqing Zhang

State Key Laboratory of Water Resources and Hydropower Engineering Science, Wuhan University, Wuhan, PR China (nongxizhi@whu.edu.cn;dgshaowhu@163.com;xiaoyi@whu.edu.cn;zhonghua21cn@126.com; 963793246@qq.com)

The safety of the daily water quality of the Middle-Route (MR) of the South-to-North Water Diversion Project of China (SNWDPC) profoundly affects the health and life of 53.1 million people using water from the MR canals. Under normal operating conditions, the daily water quality in SNWDPC MR is associated with many factors that are expensive to monitor. It is crucial to find a method to forecast daily water quality with limited observed data in the SNWDPC MR effectively for water safety and management. In this paper, we proposed a novel model, which was based on the back propagation neural network (BPNN) and optimized by the Cuckoo Search (CS) algorithm, to forecast daily water quality in the SNWDPC MR. Nine water quality indicators, including conductivity (CD), chlorophyll content (CC), dissolved oxygen (DO), dissolved organic matter (DOM), pH, permanganate index (PI), turbidity (TB), total nitrogen (TN), were the predictand. Seven influencing external factors, including air temperature (AT), PM 2.5, rainfall (RF), sunshine duration (SD), water flow (WF), wind velocity (WV), water vapor pressure (WVP) were the default predictors to the model. A total number of each predictand and predictor was 188 data in 94 days. We compared the proposed CS-BP model with other three models (i.e. the traditional BP model, the general regression neural network model and the particle swarm optimization back-propagation) by the case study of the SNWDPC MR. The correlation coefficients between two different indexes were calculated and different predictors of each predictand were selected according to the descending order of the correlation coefficients to compare the forecast performance with the default predictors. The comparison showed that 5 water quality indicators had lower Root Mean Squared Error (RMSE) values and Mean Absolute Percentage Error (MAPE) values under new predictors than the default but other 4 indicators were not. Under the default data proportion, 150:38 (training data: testing data), the CS-BP model had lowest RMSE and MAPE values of each water quality indicator among four models. When the training data reduced from 150 to 140, and from 140 to 130, the CS-BP model maintained the highest forecast accuracy. The results showed that among four models, the CS-BP model performed best in forecasting each water quality indicator and this model is effective to forecast water quality with limited observed data of predictors such as water quality in the SNWDPC MR.