

Research on the Modeling of Xiaosha River Artificial Wetland and the Scheduling Program of Water Quality and Quantity

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Abstract- During the research of Xinxue River artificial wetland of Nansi Lake, through consulting literature and inferred analysis, BP neural network forecasting model of Xiaosha River artificial wetland is selected to carry on follow-up study. Because Xiaosha River artificial wetland is in the planning and design stage, and the establish of BP neural network forecasting model requires large amounts of data, therefore this paper built virtual data of influent quantity and quality and effluent quality, and studied on the modeling of Xiaosha River artificial wetland and the scheduling program of water quality and quantity.

Keywords- BP Neural Network; Virtual Data; Construction of Model; Scheduling of Water Quantity and Quality

I. INTRODUCTION

South-to-North Water Diversion Project is a major strategic project to alleviate the severe water shortages in northern China. As water conveyance channel and Storing Lake in east line project, Nansi Lake's water quality is directly related to the country. Recent monitoring results show its water quality has a big gap with state water quality requirements. Wetland technology as a new type of sewage purification and treatment is now widely used in the water governance of basin-scale river and lake water. Xiaosha River constructed wetland belongs to the sequence of the Nansi Lake estuary Constructed Wetland, and is demonstration topic to establish wetland models and scheduling program of water quality and quantity.

Currently Xiaosha River's water quality can't reach water diversion water quality and its quantity changes largely. So establishing wetland models and scheduling program of water quality and quantity is positive to provide a theoretical basis and improve regional environmental.

II. THE CHOICE OF THE TYPE OF WETLAND MODELS

Currently wetland water quality prediction model is still confined to the mechanism model, but it is difficult to accurately simulate the complex process of pollutants. BP neural network can predict complex nonlinear dynamical systems, and its numerical stability and accuracy have greatly improved contrasting with deterministic mechanism model. So BP neural network can be used in the study course of water quality and quantity forecasts, simultaneously can provide an important scientific basis for water quality and quantity scheduling scheme.

III. THE CONFIRMATION OF MODEL PARAMETERS

A. The Confirmation of Virtual Data

Nansi Lake artificial wetland design information [1] shows, there are both similarities and differences between Xiaosha River and Xinxue River constructed wetland. Currently reference engineering, Xinxue River constructed wetland, has been completed and put into operation, received a large number of monitoring data, and established neural network prediction model and the quality and quantity scheduling scheme [2-3].

The establishment of Xiaosha River constructed wetland BP neural network prediction model, need water intake data and water effluent quality data. Water intake data include actual intake quality data and virtual intake quantity data. Water effluent data are built by two steps: firstly based on both similarities, prediction model has same effluent data with reference engineering; secondly based on both differences, effluent data is adjusted and virtual effluent quantity data is built completely.

B. The Confirmation of Hidden Layer Nodes

Using Matlab software, the study is divided into three conditions including February to May, June to September and October to December, and the condition of February to May was regarded as an example. To improve the accuracy and performance of the BP neural network, the model used premnmx function to normalize these data before establishment [4]. The normalized data were distributed in the range [-1, 1].

To ensure the performance of the neural network training, the model used a neural network which had three hidden layers. During operation, the conformity of the wetland operating conditions was by adjusting intake water quality and quantity,

scilicet input layer neuron was 2 (expressed in m). Intake water quantity, COD_{Cr} and ammonia nitrogen were regarded as the output of the model, scilicet output layer neuron was 3 (expressed in n). According to the empirical formula $n_1 = \sqrt{n + m} + a$ [5-6], the number of hidden layer nodes should be between 3 and 13, 'a' is a constant between 1 and 10.

In order to ensure accuracy, hidden layer nodes should be trained. In this study, the network maximum number of iterations was set to 10000 times, the training objectives error was 0.001 and learning accuracy was 0.1. When selecting the number of nodes of 3 to 13 to train the network, network convergence and inspection error didn't reach accuracy requirements. But when hidden layer nodes were 9, the network training had high performance and then network training error is small. So February to May Water quality prediction model hidden layer node number was 9.

C. The Confirmation of Model Topology

Xiaosha River wetland model input layer number was 2; output layer number was 3. The model's topology was shown in Figure 1.

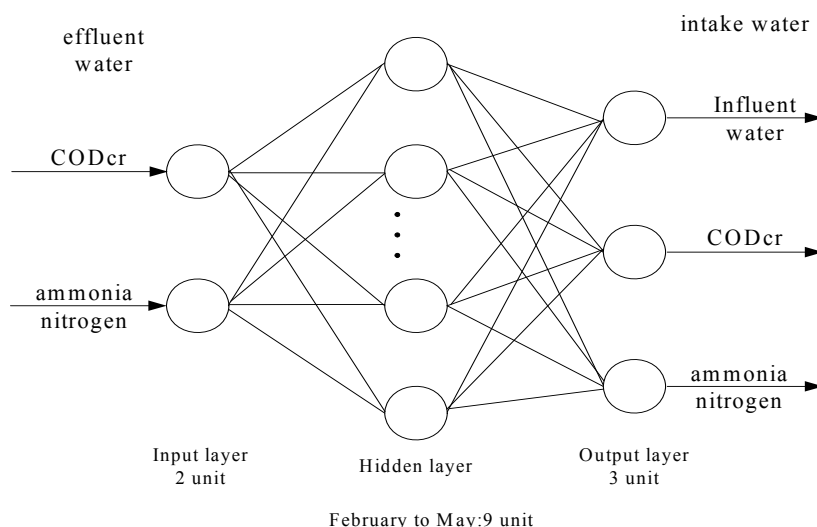


Fig. 1 Xiaosha River constructed wetland neural network model topology

After normalization processing using premmx function, model training virtual sample data were in the range of between -1 and 1. The transfer functions of the hidden layer selected tansig function, the transfer function of the neuron selected purelin function. The study used newff function to create network, the network can automatically initialize the weights and thresholds and the default value was 0 [7-8].

IV. MODEL'S TRAINING TEST

A. Error analysis of the training function

By changing the training function and comparing training results, the study eventually determined the model BP neural network learning algorithm which had the best performance and the smallest relative error. The training times and errors of training function are shown in Table I.

TABLE I FEBRUARY TO MAY TRAINING ERROR OF DIFFERENT FUNCTIONS

Algorithmic functions		traingdx	trainrp	traincgf	trainscg	traingda
The number of training		386	259	274	263	314
The amount of water The actual value: 50630(m ³ /d)	Predictive value	55655	55363	63051	58964	46326
	Absolute error	5025	4733	12421	8334	-4303
	Relative error (%)	9.93	9.35	24.53	16.46	-8.50
COD_{Cr} The actual value: 33.7(mg/L)	Predictive value	38.47	38.07	38.51	39.67	29.79
	Absolute error	4.77	4.37	4.81	5.97	-3.91
	Relative error (%)	14.14	12.96	14.29	17.70	-11.60
Ammonia nitrogen The actual value: 1.86(mg/L)	Predictive value	1.56	1.68	1.78	1.51	1.10
	Absolute error	-0.30	-0.18	-0.08	-0.35	-0.76
	Relative error (%)	-15.91	-9.55	-4.32	-18.81	-40.94

The analysis of the above relative error showed that the neural network prediction model of February to May used trainbr training function, because of its high convergence and fitting ability.

B. The Analysis of Inspection Error

Seen by the above studies, Xiaosha River constructed wetland neural network model structure had three-layer neural network. And its number of neurons in the input layer was 2 and its number of neurons in the output Layer 3. The transfer function of hidden layer neurons was logsig and the transfer function of output layer neurons was purelin. And the maximum learning number of the network is 10000, the target error is 0.001, and the learning rate is 0.1. So in February to May hidden layer node was 9 and the network training was trainrp function.

In order to test its accuracy, the model should be trained and tested. Taking the first to the seventh group of virtual data as training samples, the eighth group of virtual data as testing sample was trained through above model parameters. After 259 training the network reached training accuracy, predictive output value was got and was compared with the found.

After using the samples tested of Xiaosha River constructed wetland in February to May to forecast, forecast data was got, the relative error of the amount of water was 9.35%, the relative error of the COD_{Cr} was 12.96%, the relative error of the ammonia nitrogen was 9.55% and they were less than 20% and within the acceptable range.

V. THE SCHEDULING SCHEME OF WATER QUALITY AND QUANTITY

A. The Scheduling Process of Water Quality and Quantity

To ensure the stability of the entire system, the sewage concentration and flow rate into the wetland system must be legitimately controlled. Taking Surface water Class III water quality requirements as constraints, established prediction model was used to research water quality and quantity scheduling scheme.

The specific embodiment of the scheduling scheme was: when entering water quality and quantity exceed requirements, entering water through upstream ecological channel is introduced to the ecological retention pond, and conducts water regulation and storage and water purification. When entering water quality exceed entering water requirements, but is greater than Grade III standard, the river inflows Xiaosha River constructed wetland and carries on depth treatment.

B. The scheduling parameters of water quality and quantity

When the effluent water COD_{Cr} reached 20 mg/L and the effluent water ammonia nitrogen reached 1.0 mg/L, the trained model in February to May was used to forecast after 259 training for the purpose of the training accuracy. The predicted results and relative errors of the prediction model are shown in Table II.

TABLE III THE PREDICTIVE VALUE OF CONSTRUCTED WETLAND WATER QUALITY INDICATORS

Predictions	Index	Predictive value	Model relative error
February to May	The amount of water	55362	9.35
	COD_{Cr}	38.07	12.96
	The ammonia nitrogen	1.68	9.55

Table II shows: in order to ensure venting water quality reach Class III water quality requirements, the influent water of the constructed wetland shouldn't be more than 55362 m³/d from February to May, at the same time venting water quality should meet $\text{COD}_{\text{Cr}} \leq 38.07$ mg/l, the ammonia nitrogen ≤ 1.68 mg/l. When the venting water can't meet the above-mentioned requirements, the water of the river can be hold up by upstream rubber dam, the entering water through upstream ecological channel can be introduced to the ecological retention pond and is conducted water regulation and storage and water purification.

When Xiaosha River constructed wetland puts officially into operation, actual monitoring data can be used to test and correct the model and scheduling scheme. So this study has theoretical guidance for the design, construction and operation management of Nansi Lake constructed wetland.

VI. CONCLUSION

From the viewpoint of system science, planning Xiaosha River conducts seasonal partition and establishes wetland models and scheduling program of water quality and quantity on the basis of BP neural network and virtual data. This research solves the model problem of constructed wetland, which is still in the planning and design stage, and introduces the research method of virtual data among the research process of Nansi Lake artificial wetlands.

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