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Evaluation on Total Amount Control of Marine Water Pollution based on ANN and Genetic Algorithm

Hyunwoo Kim*

Democritus University of Thrace, 671 00 Xanthi, Greece

**corresponding author*

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Abstract: With rich resources and superior habitats, coastal areas have become the most important and concentrated areas for economic and development. At present, a major problem affecting the economic development of coastal areas is the blind development of the coastal economy and the accidental introduction of a large number of land pollutants discharged into the sea and causing marine pollution, which has damaged the ecological balance. Artificial Neural Network (ANN) and genetic algorithm are suitable for solving the problem of water pollution. In this paper, two methods were used to control the total amount of water pollution in marine areas. In this paper, the current situation of the total amount control of water pollution in the sea area was studied firstly, and then the artificial neural network and genetic algorithm were fused to obtain the genetic neural network using the auxiliary combination method. For the study of total amount control of water pollution in the sea area, this paper first calculated the water environment capacity of the sea area, then used genetic neural network to optimize the total amount distribution of water environment, and calculated the pollution concentration standards at different control points. The experimental part applied the total amount control method of sea water pollution in this paper to the management of sea water pollution, predicted the water pollution situation of the sea area, and compared it with the real situation. The results showed that the total amount control method of sea water pollution combined with artificial neural network and genetic algorithm can effectively reduce the water pollution situation of the sea area. The chemical oxygen demand in the sea area decreased from 1.65mg/L to 1.16mg/L, and the phosphate content in the sea area decreased from 0.028mg/L to 0.016mg/L.

1. Introduction

The 21st century is the century of utilizing the ocean, and the ocean has become an important

point of economic growth. However, with the rapid development of the economy, industrial and agricultural wastes would also increase, and the waste treatment technology is far behind the pace of economic development. In view of the current situation of marine pollution, action must be taken, otherwise the marine environment would deteriorate further. It is necessary to analyze the characteristics of the ocean, determine the pollution capacity of the marine environment, and take appropriate control measures.

At present, there are many researches on water pollution control. Martini Sri reviewed the application progress of membrane technology in sewage treatment [1]. He Mingjing discussed the application of biochar in water pollution control in the context of sustainable development [2]. Ji Mengzhi summarized and evaluated the role of bacteriophage in controlling sewage treatment system [3]. Long Bui Ta considered the inverse problem in controlling river water pollution [4]. Chen Tao studied the role of konjac glucomannan/graphene oxide in water pollution control [5]. Rink Karsten integrated a large number of heterogeneous data sets related to various hydrological divisions into a virtual geographical environment for water pollution control [6]. Although there are many studies on water pollution control, how to control the total amount of water pollution in the sea area needs further study.

ANN and genetic algorithm are applied to water pollution. Kadam AK applied artificial neural network and multiple linear regression technology to predict whether the groundwater quality in the river basin is suitable for drinking [7]. Ukun Ozel Handan used artificial neural network to predict heavy metal pollution in the Balding River [8]. Sotomayor Gonzalo used genetic algorithm to evaluate water quality [9]. Zhang Xuan applied the theory of combining back-propagation neural network and genetic algorithm to the dam seepage prediction model [10]. Although ANN and genetic algorithm are widely used in water pollution, how to apply ANN and genetic algorithm to total amount control of sea water pollution needs further research.

In order to carry out more accurate research on the total amount control of water pollution in the sea area and find the best allocation scheme of total amount of pollution, this paper combines artificial neural network and genetic algorithm to study the total amount control of water pollution in the sea area. This paper analyzes the definition of marine water pollution and the causes of marine water pollution, introduces the principles of artificial neural network and genetic algorithm, and combines artificial neural network and genetic algorithm to obtain genetic neural network. This paper also calculates the water environmental capacity of the sea area, then uses genetic neural network to allocate the types based on the calculated water environmental capacity, and verifies the effectiveness of the total amount control method of water pollution in the sea area in the experimental part.

2. Current Situation of Total Water Pollution Control in the Sea Area

The comprehensive control of marine pollution means controlling the quality of the marine environment, making proper use of the ecological resources of the marine area (i.e., the pollution capacity), and systematically controlling the increase or decrease of the total amount of pollutants in the territory, the quantity and speed of pollutants discharged into the sea, the protection or recovery of the marine environment, and the full utilization and distribution of the marine environmental resources, which are in line with the socially acceptable degree of utilization of marine functions.

The deterioration of the marine environment has attracted the attention of the government. As early as the early 1970s, they began to control the concentration of pollutants to control the discharge of pollutants. Relevant laws and regulations and the hierarchical management system responsible for the marine environment have already existed. Marine pollution mainly comes from the discharge of land pollutants. Since the implementation of standardization control, the

concentration of land pollutants has decreased, but the monitoring shows that the total amount of pollutants in coastal waters has increased for two reasons. First, the concentration and range of pollution sources are not considered. Second, the possibility of reducing the concentration of pollutants through dilution is not ruled out, and the total concentration of pollutants in the region cannot be guaranteed to be lower than the maximum allowable emission. Only by controlling the total amount of pollutants can people effectively improve the marine environment and reduce pollution.

Calculating the pollution capacity of the sea area is the key to comprehensive control, and accurate calculation of the pollution capacity of the sea area is the basis and direction of current comprehensive control. Total amount control describes the mathematical expression of the water quality reaction system according to the principle of mass conservation, that is, the generation of plane diffusion transfer. This method is more suitable for calculating the total pollution of shallow water. Calculating the total amount of pollutants that pollute the ocean is a more effective control of the polluted marine environment and an important basis for determining the emissions of each source. The emissions of each source are added according to the total amount of pollutants. Considering the characteristics of the source and local economic and living conditions, reasonable distribution is also important.

3. Genetic Neural Network

3.1. Artificial Neural Network

The artificial neural network has high learning ability when studying nonlinear events, and seeks the object sample with the minimum average deviation between the actual and expected learning network output. BP neural network (Back Propagation) is the most commonly used artificial neural network [11].

The structure of BP neural network mainly includes three layers. The communication and feedback between layers are closely related, and the neurons in the same layer are not connected with each other. Communication between layers is one-way, but information transmission is two-way. The algorithm learning process of BP neural network extends in the positive and negative directions. In the direct propagation process, X is the input information sample corresponding to each neuron in the input layer. The hidden layer is processed according to the weight value to obtain the results of the hidden layer. In order to obtain a small single output, the results are transferred to the output layer layer by layer. If the difference between the output result and the expected result is large, it is necessary to switch to back propagation and calculate the error signal in the opposite direction according to the neuron connection mode to obtain a satisfactory result [12].

3.2. Genetic Algorithm

Genetic algorithm introduces optimized parameters through cloning and screening high-configuration individuals, hybrids and genetic mutations to form a coding level group and select appropriate configuration functions according to the characteristics of sample objects. These clones maintain the high structural value of individuals, thus forming new groups. They have the genetic information of their parents, and exceed their parents, so the population can be updated continuously until the best solution is found [13].

3.3. Combination of Artificial Neural Network and Genetic Algorithm

Generally speaking, there is a strong nonlinear relationship between input and output. The

weights are determined by neural network. The data samples are trained, and the best decisions are determined according to different stages of the process. Genetic algorithm has certain advantages in solving the maximum event problem, with greater flexibility and infinity, but the selection and function evaluation of coding chromosome is difficult. The combination of these two methods forms a complementary and integrated genetic neural network [14].

This paper selects the auxiliary combination method to combine genetic algorithm and artificial neural network. This method makes full use of genetic algorithm to preprocess samples, optimize sample data, and then use neural network to solve the problem.

The steps of using genetic algorithm to optimize neural network weights are shown in Figure 1.

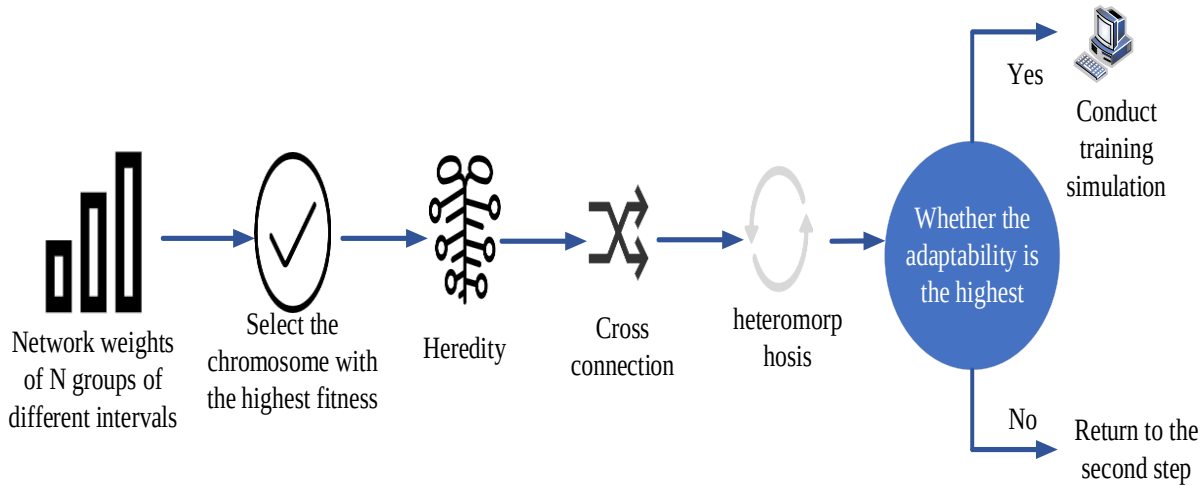


Figure 1. Steps of optimizing neural network weight using genetic algorithm

A part of the total sample is randomly selected and the group is coded according to the effective coding method. The genetic sequence represents the state of the weighted threshold distribution of the network, and the chromosome (object) represents the set of weighted thresholds of the neural network.

The error function of each chromosome of the neural network is calculated. The group matching the target value is selected, and the adaptive function value of the group is further determined.

The group highly adapted to the target would be regarded as the parent generation, and the next step is to pass them on to the offspring.

For the next generation, crossover operators and variables are used to process and calculate.

It is necessary to evaluate whether the results meet the completion objectives. After the goal is reached, it is over and the next step is continued. If it is not enough, it is necessary to repeat until the result is satisfactory.

4. Calculation of Water Environment Capacity of Sea Area

The aquatic environmental capacity of the basin refers to the maximum exposure to water pollutants under the condition of meeting the water quality requirements, which indicates that the quantity of specific pollutants that may exist in the environment is limited. In other words, the capacity of the environment can be quantified according to specific ecological functions, and the amount of pollutants that may exist in each ocean is different. In areas with active water exchange and abundant water resources, the same space area may contain more pollutants, and vice versa.

The calculation of allowable emissions is the basis of complete control. “Allowable discharge” refers to the amount of pollutants that may be contained in water under current discharge conditions when the concentration of pollutants in water does not exceed the environmental quality standard

determined by marine experts. The first is the water quality standard, which is the condition for calculating the allowable discharge. The second problem concerns the dynamic conditions of coastal wastewater collection and treatment, which is the objective condition for calculating the allowable discharge.

This document uses the method of regional standard control to calculate the capacity of the aquatic environment in the marine area. This method introduces a contribution coefficient and defines the capacity problem as a linear programming problem. Regional control ensures that the total amount of pollutants discharged from each functional area of water is the largest and complies with relevant environmental standards. The regional standard control method is calculated as follows:

(1) Selection of water quality control points

According to the sustainable development requirements of the basin, the basin is usually divided into different areas according to various functions. Each functional area has its own water pollution standards. Monitoring stations need to be set up in the functional area to detect the water quality of the area at any time.

(2) Calculating response coefficient

If the drain outlet is a pollution load outlet, there is $x_k = 1$. If the drain outlet is not loaded, there is $x_k = 0$. Then, in this case, the water quality prediction model is used to calculate the concentration distribution of water pollution and determine the concentration value of water quality control points. People can change the sequence and repeat the above steps to calculate the response factor for each sequence at each checkpoint.

(3) Linear programming method for solving the maximum environmental capacity of a region

$$\max P = \sum_{i=1}^{m} P_i \tag{1}$$

$$\sum_{i=1}^{m} \propto_i (x_k, y_k) P_i \leq C_k \tag{2}$$

$\propto_i (x_k, y_k)$ is the response coefficient of K point and source point i; P_i is the allowable emission of source point i; C_k is the allowable concentration value at k point.

$$\Delta P_i = P_{0i} - P_i \tag{3}$$

ΔP_i represents the difference between the current emission and the allowable emission of source point i. If $\Delta P_i > 0$, it should be reduced by ΔP_i. If $\Delta P_i < 0$, there is surplus, and there is no need to reduce it. If $\Delta P_i = 0$, there is no margin.

5. Optimization of Total Allocation Based on Genetic Neural Network

The main idea of water pollution control is to optimize the configuration of various drainage facilities to ensure compliance with the daily environmental water quality standards of the region, and control the total allowable discharge of major pollutants in the region according to the environmental capacity. If the concentration of pollutants at each control point does not exceed the environmental quality standards specified by the relevant functions, it means that the total emission of the whole region would reach the standard level [15].

This paper avoids calculating the total allowable emission of the region, but estimates the source intensity from the concentration of the control point to control the total amount of pollutants in the whole region.

Generally speaking, based on the control principle of genetic neural network, the intensity of each pollution source is encoded as a string, which is used as the operating object in the genetic neural network operating environment, and the biological genetic evolution mechanism is used to

automatically adjust the intensity of pollution sources. If the pollution concentration at the control point fully complies with the environmental quality standards, the total allowable emission is the highest in the region. This source intensity configuration is the best, and it is also the best possible solution to control general problems. The total amount control steps of genetic neural network are as follows:

The control points shall be determined according to the requirements of the functional area, and the seawater quality standards applicable to each control point shall be formulated.

The difference between the calculated concentration and the standard is used as the standard to determine the chromosome quality in the genetic neural network algorithm. That is to say, individual adaptability is calculated according to differences. The smaller the gap, the greater the applicability.

The total proximity between the calculated concentration and the standard concentration is:

$$\mathrm{Err_k} = \frac{1}{2}\left(\sum_{i=1}^{m} C_{ski} - \alpha_i(x_k, y_k) \cdot P_i\right)^2 \tag{4}$$

The individual fitness function is:

$$\mathrm{Fitness} = \mathrm{MaxErr} - \mathrm{Err} \tag{5}$$

C_{ski} is the standard concentration in the area where control point K is located; $\alpha_i(x_k, y_k)$ is the k-point response coefficient of i pollution source; P_i is the allowable emission of source i; $\mathrm{Err_k}$ is the average total deviation of control point k. The smaller the Err, the closer the calculation is to the standard concentration.

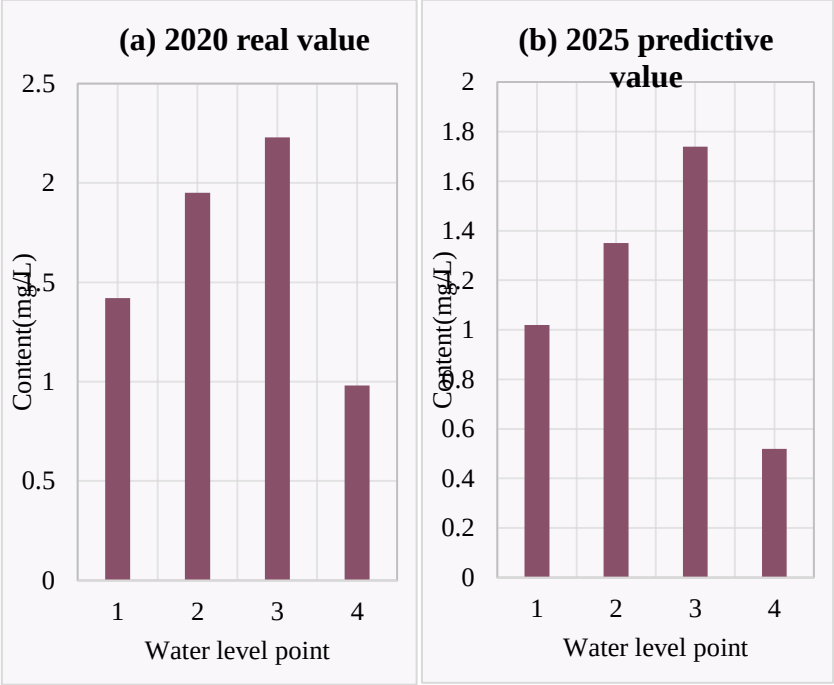
The pollution source intensity of each emission unit is encoded into a chain by genetic algorithm. The algorithm gradually evolves according to the calculation process of genetic algorithm to find the appropriate chromosome. When the difference between the calculated concentration and the standard concentration reaches a very small value, the evolution stops. At each control point, the absolute difference between the concentration and the standard is calculated, and then the average difference is calculated, which is used to evaluate the advantages and disadvantages of individuals. According to the general emission control requirements, if there are several best solutions that can maximize the total local emissions, they can be solved by comparing the sum of each pollution source.

6. Experiment on Total Amount Control of Sea Water Pollution

A certain sea area is the research object. Four water level points are selected in the sea area to investigate the water pollution status of the sea area in 2020, and predict the water pollution status of the sea area in 2025 after adopting the genetic neural network total water pollution control method in this paper.

6.1. Chemical Oxygen Demand in Sea Area

The results of the actual value of Chemical Oxygen Demand (COD) in 2020 and the predicted value of chemical oxygen demand in 2025 are shown in Figure 2.



(a) Real value of COD in the sea area in 2020

(b) Predicted value of COD in sea area in 2025

Figure 2. COD in sea area

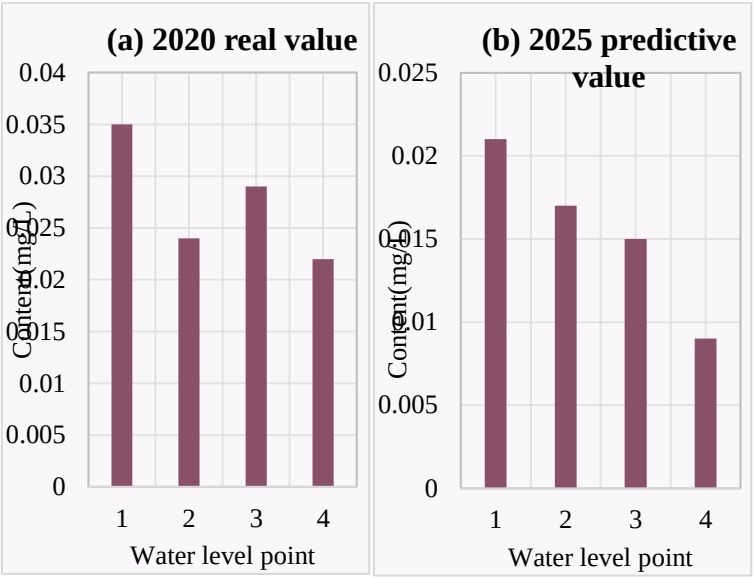
Figure 2 (a) shows the real value of COD in the sea area in 2020, and Figure 2 (b) shows the predicted value of COD in the sea area in 2025.

The actual COD content of water level point 1 in the sea area was 1.42mg/L in 2020, and the COD content in the sea area was predicted to decrease to 1.02mg/L in 2025. The actual COD content of water level point 2 in the sea area was 1.95mg/L in 2020, and the COD content in the sea area was predicted to decrease to 1.35mg/L in 2025. The actual COD content of water level point 3 in the sea area was 2.23mg/L in 2020, and the COD content in the sea area was predicted to decrease to 1.74mg/L in 2025. The actual COD content of water level point 4 in the sea area was 0.98mg/L in 2020, and it was predicted that the COD content in the sea area would decrease to 0.52mg/L in 2025. In 2020, the average COD in the sea area was 1.65mg/L, and in 2025, the average COD in the sea area was 1.16mg/L.

It can be seen from the comparative data that the total amount control method of water pollution based on genetic neural network in this paper can effectively control water pollution, and the COD content of the sea area can be greatly reduced.

6.2. Phosphate Content in Sea Area

The actual value of phosphate content in the sea area in 2020 and the predicted value of phosphate content in the sea area in 2025 are shown in Figure 3.



(a) True value of phosphate content in the sea area in 2020

(b) Forecast value of phosphate content in sea area in 2025

Figure 3. Phosphate content in sea area

Figure 3 (a) shows the true value of phosphate content in the sea area in 2020, and Figure 3 (b) shows the predicted value of phosphate content in the sea area in 2025.

For the content of phosphate in the sea area, the true value of the content of water level point 1 in 2020 was 0.035mg/L, and the predicted value of the content in 2025 was 0.021mg/L. The actual content of water level point 2 in the sea area in 2020 was 0.024mg/L, and the predicted content in 2025 was 0.017mg/L. The actual content of water level point 3 in the sea area in 2020 was 0.029mg/L, and the predicted content in 2025 was 0.015mg/L. The true content of water level point 4 in the sea area in 2020 was 0.022mg/L, and the predicted content in 2025 was 0.009mg/L. In 2020, the average phosphate content in the sea area was 0.028mg/L, and in 2025, the average phosphate content in the sea area was 0.016mg/L.

It can be seen from the comparative data that the total amount control method of water pollution based on genetic neural network in this paper can effectively control water pollution, and the phosphate content in the sea area can be greatly reduced.

7. Conclusion

In this paper, the auxiliary combination method was selected to combine genetic algorithm and artificial neural network to obtain genetic neural network. The method of regional standard control was used to calculate the capacity of the aquatic environment in the marine area, select the water quality control points, calculate the response coefficient, and use the linear programming method to solve the regional maximum environmental capacity. The genetic neural network was used to optimize the regional total emission distribution and get the best solution. The experiment in this paper showed that the combination of genetic algorithm and artificial neural network can effectively reduce water pollution and control water pollution.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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