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Computer-aided analysis method of nitrogen pollution in an ecological river

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ABSTRACT

The computer-aided analysis method is used to analyze the nitrogen pollution in the ecological river, which provides a basis for solving that problem. Taking the Shanzi Reservoir in the east of Fujian Province as the research area, the numerical simulation was used to simulate and analyze the spatial and temporal distribution of the flow field and pollutant concentration field of the ecological river caused by nitrogen pollution accident. Based on the grey correlation system theory, a computer-aided model for predicting nitrogen pollution in an ecological river was constructed, and the nitrogen pollution situation was analyzed. The results show that this method can accurately analyze the nitrogen pollution concentration and water quality indicators in different waters at different times in the study area. The method has high analysis efficiency and precision, and good analysis stability. The analysis results can provide a favorable basis for controlling nitrogen pollution in the ecological river.

Keywords: Ecological river; Nitrogen pollution; Computer-aided; Building model; Efficiency; Accuracy

1. Introduction

In recent years, ecological river pollution accidents have occurred frequently. According to statistics, from 2001 to 2004, 3988 ecological river water pollution accidents occurred in China. Since the end of 2005, an environmental pollution emergency has occurred on average every 2 d in China, and 70% of these incidents are ecological river pollution accidents [1,2]. The typical cases are the Songhua River pollution incident and the ecological river pollution incident in Poyang, Jiangsu. The ecological river pollution problem has become an important factor that restricts economic development, endangers the health of people, and affects social stability [3]. Ecological water is an important resource to support human health, promote economic development and ecological diversity. However, due to the increasing river pollution, environmental and socio-economic development are affected [4]. Comprehensive and accurate evaluation of ecological river pollution is of great significance for protecting ecological rivers [5]. At present, ecological river pollution has become a key issue of global concern, and research on ecological river pollution has gradually deepened [6].

Eutrophication and harmful algal blooms (water blooms, red tides, green tides) are global water environmental issues, mainly related to anthropogenic excess nitrogen emissions [7,8]. With the increase in population and socio-economic development, various land-based pollutants such as nitrogen have increased, and ecological rivers such as lakes, reservoirs, estuaries and inshore waters are rich in nutrients [9–11]. The increased primary production (organic carbon) will lead to eutrophication problems. Affected by factors such as changes in pollution sources and dam construction, nutrient salt structures (nitrogen, phosphorus, and silicon) in water also change in varying degrees and directions, which in turn affects the structure and function of ecosystem communities [12,13] and increase the ecological risk of algal blooms. Nutrient nitrogen is the main biogenic element,

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but its excessive anthropogenic emissions have caused a series of environmental and ecological effects [14], including excessive water quality, acidification, algal blooms, hypoxia, malodor, and damage to biological diversity [15]. It will also affect the use of ecological river resources such as industrial and agricultural and domestic water, aquaculture, tourism, and water transportation, and the sustainable development of the regional economy [16,17]. The problem of eutrophication in ecological rivers in China is becoming increasingly prominent. Harmful algal blooms mainly occur in the densely populated, economically developed, and heavily polluted Yangtze River basin and eastern coastal areas. Extensive research has been carried out at home and abroad on the eutrophication mechanism and its regulation technology [18]. However, the fundamental way to solve the problem is to reduce the input of external pollution. At home and abroad, many methods have been developed in the quantitative research of nitrogen pollution in ecological river basins, including the coefficient method, model method, and measured method [2,19]. Commonly used pollution load models include empirical models such as the Global River Nutrient Export Model (Global NEWS) and SPARROW model suitable for regional assessment. Such models can simulate nitrogen export, channel migration and it is final fluxing into the sea. Mechanism models such as AnnAGNPS, SWAT models, mainly simulate the nitrogen migration and transformation process and output load in the basin. These internationally developed models usually require detailed basic data and hydrological data. At present, small basins in China generally suffer from the problems of lack of measured data, lack of basic information, and difficulty in estimating non-point source pollution. It is urgent to establish a quantitative method for nitrogen pollution prevention and control in ecological rivers [20,21]. Therefore, a computer-aided analysis model for predicting nitrogen pollution in ecological rivers was constructed, and the analysis of nitrogen pollution was shown to provide a reference for related departments to study and handle river pollution accidents [22].

2. Material and methods

2.1. Overview of the study area

Shanzi Reservoir is located in the eastern part of Fujian Province and belongs to the subtropical monsoon climate zone. The average annual temperature there is between 14.7°C~19.4°C, the annual rainfall is between 1,310~1,672 mm, and the flood season is from April to September. Shanzi Reservoir has an average water depth of 30 m and a total storage capacity of 172 million m^3. According to the related data, the TN content in the core of the reservoir from 2006 to 2012 was 0.14 to 2.17 mg L^{-1}, and the water pollution problem was prominent. The area controlled by the Shanzai dam site is 1,646 km^2, and its slope ranges from 0° to 63°. Most of the areas are middle and low mountains, and the average slope of the river is large. The rivers directly into the reservoir include Rixi, Hukou and Huang Didongxi. The basin mainly involves 11 towns, including Rixi, Dahu, Tingping, Xiaocang, Feizhu, Hukou, Xiazhu, Hetang, Shanyang, Zhuoyang and Dajia, accounting for 91% of the total area of the basin. Through data analysis and practical investigation, the main pollution sources in Shanzai basin are domestic sewage, chemical fertilizer loss, livestock breeding and air settlement, while the pollution sources in the reservoir area are river input, non-point sources around the reservoir area, air settlement and sediment release. This serious nitrogen pollution threatens the ecological environment. Therefore, Shanzai Reservoir is taken as the research area.

2.2. Analysis method of nitrogen pollution

2.2.1. Two-dimensional hydrodynamic model

When neglecting the effects of wind stress, vortex viscosity, and local friction, the basic equations for two-dimensional hydrodynamic calculations are as follows:

$$\frac{\partial z}{\partial t}+\frac{\partial}{\partial x}\left[uh\right]+\frac{\partial}{\partial y}\left[vh\right]=0 \quad (1)$$

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial z}{\partial y}+g\frac{\partial z}{\partial x}-\Omega v+\frac{gu\sqrt{u^2+v^2}}{hC^2}=0 \quad (2)$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+g\frac{\partial z}{\partial y}+\Omega u+\frac{gv\sqrt{u^2+v^2}}{hC^2}=0 \quad (3)$$

Eq. (1) is a continuity equation and Eqs. (2) and (3) are momentum equations. z is the water level, h is the depth of the water, u and v is the average velocity of the vertical lines in the direction of x and y, respectively, t is the time, C is the Chezy coefficient, $C = R^{1/6}/n$, n is the roughness of the river bed, Ω is the Coriolis force coefficient, $\Omega = 2\omega\sin\Psi$, ω is the autobiographical speed of earth, Ψ is latitude.

The above partial differential equation can be solved numerically according to the given initial boundary conditions. On the bank boundary, based on the impermeability of the solid wall, the normal component of the velocity is set to 0, that is, $V_n = 0$. On the upper and lower boundaries, the hydrological data obtained by actual observation or interpolation are input. The initial conditions are the velocity and water level at the initial moment of the simulation, $u = uo(x,y)$, $v = vo(x,y)$, $z = zo(x,y)$.

2.2.2. Two-dimensional nitrogen pollution diffusion model

The two-dimensional non-steady-state water quality model is used to represent the diffusion process of nitrogen pollution. It can be used to predict the water quality of rivers, lakes, and other water bodies. The basic equation is:

$$\frac{\partial\left[hp\right]}{\partial t}+\frac{\partial\left[uhp\right]}{\partial x}+\frac{\partial\left[vhp\right]}{\partial y}=\frac{\partial}{\partial x}\left[E_x h\frac{\partial p}{\partial x}\right]+\frac{\partial}{\partial y}\left[E_y h\frac{\partial p}{\partial y}\right]-Khp+sh \quad (4)$$

where $p(x,y,t)$ (mg m^{-3}) is the concentration of the pollutant, $E_x(x,y)$ and $E_y(x,y)$ is the turbulent diffusion coefficient in the direction x and y, $K(x,y)$ is the coefficient of self-purification (or precipitation), $s(x,y)$ (mg (m^{-3} s^{-1})) represents the amount of pollution in the water body.

For any point (or micro water mass) (x,y) in space, the change rate of nitrogen pollutant average concentration $p(x,y)$ with time is expressed as $\partial p / \partial t$. Equation (4) shows the relation between $\partial p / \partial t$ and the translation rate, turbulent diffusion and source leakage rate of nitrogen pollutant at that point. This equation is also known as the two-dimensional water quality basic equation or two-dimensional diffusion and migration equation, which expresses the average nitrogen pollutant concentration in the water in each direction of the two-dimensional plane. The boundary conditions are below. At the closed boundary, suppose that there is no pollutant expansion and transportation in the normal direction of the coastline, then $\partial p / \partial t = 0$. At the open boundary, the pollutant concentration condition is expressed as $p = po(xo,yo,t)$, and (xo,yo) is the coordinates of the open boundary point.

Eqs. (1)–(4) together constitute a two-dimensional numerical simulation model of nitrogen pollution diffusion, and the spatial and temporal distribution of the flow field and concentration field of nitrogen pollutants in the polluted water area can be obtained by numerical methods.

2.2.3. Prediction model of nitrogen pollution in ecological river based on computer-aided analysis

Based on the spatiotemporal distribution of the flow field and the concentration field of nitrogen pollutants in the polluted water, a computer-aided analysis model was used to analyze the nitrogen pollution in the water of the study area. In the process of forecasting nitrogen pollution, the computer-aided analysis and prediction model was constructed based on the grey correlation theory. It does not depend on hydrogeological parameters and aquifer information and it can determine the approximate functional relationship between the forecast factors and influencing factors based on past behaviors of the ecological river system. Using the grey correlation system theory, the random variable of nitrogen pollution concentration distribution in the ecological river was regarded as a grey parameter that changed within a certain range.

The differential equation model is established based on grey theory. Through a large number of sample studies and data processing, the irregular data is sorted into a regular sequence with a strong regularity. Based on the grey relational system theory, a nitrogen pollution prediction model for the ecological river was established, the specific process is as follows:

The original observation data sequence of nitrogen pollution in ecological river is set as $X^{(0)} = (X^{(0)}(1), X^{(0)}(2), \ldots, X^{(0)}(n))$. According to the migration method of ecological river and the concentration distribution of nitrogen pollution in ecological river, an accumulation and generation operation was performed on the observation data sequence, and the obtained sequence can be expressed as:

$$X^{(1)} = \left(X^{(1)}(1), X^{(1)}(2), \ldots, X^{(1)}(n)\right) \tag{5}$$

where $X^{(1)}(k) = C_0 / C\sum_{i=1}^{k} X^{(0)}(i)$, $k = 1,2,\ldots,n$. Assuming $X^{(1)}$ obeys an approximately exponential change law, the corresponding differential model can be expressed as:

$$\frac{\partial X^{(1)}}{\partial t} + \alpha X^{(1)} = u \tag{6}$$

where α is the development coefficient, u is the amount of ash interaction. The above formula is discretized, and the prediction model of nitrogen pollution in ecological river based on the grey differential equation can be expressed as:

$$X^{(0)}(t) + \alpha X^{(1)}(t) = u \tag{7}$$

Parameters α and u are solved through the least square method. Suppose $\hat{\alpha} = \left[\alpha, u\right]^T$, where T is the exponent. It can be calculated through the following expression:

$$\hat{\alpha} = \left(B^T B\right)^{-1} B^T y_n \tag{8}$$

where:

$$\hat{\alpha} = \left(B^T B\right)^{-1} B^T y_n = \begin{bmatrix} X^{(0)}(2) \\ X^{(0)}(3) \\ \vdots \\ X^{(0)}(n) \end{bmatrix},$$

$$B = \begin{bmatrix} -1/2\left[X^{(1)}(1) + X^{(1)}(2)\right. & 1 \\ -1/2\left[X^{(1)}(2) + X^{(1)}(3)\right. & 1 \\ & \vdots \\ -1/2\left[X^{(1)}(n-1) + X^{(1)}(n)\right. & 1 \end{bmatrix}$$

The above formula was used to calculate the solution of α and u. The solution is introduced it into Eq. (7), and its solution $X^{(1)}$ is the time response function, which can be expressed as:

$$\hat{X}^{(1)}(t+1) = \left(X^{(1)}(1) - \frac{u}{\alpha}\right)e^{-\alpha t} + \frac{u}{\alpha} \tag{9}$$

Based on the above formula, the time response function of $X^{(0)}$ can be expressed as:

$$X^{(0)}(t) = \left(1 - e^{\alpha}\right)\left[X^{(0)}(1) - \frac{u}{\alpha}\right]e^{-\alpha t} \tag{10}$$

The prediction result of nitrogen pollution in ecological river is:

$$\hat{X}^{(0)}(t), t = 1,2,\ldots,n \tag{11}$$

Compare the prediction sequence $\hat{X}^{(0)}(t)$ with the original data sequence $X^{(0)}(t)$, and analyze the coincidence results of the two, indicating that the model has a lower prediction accuracy. In order to improve its prediction accuracy, residual error identification was performed. The residual error sequence based on the original data sequence $X^{(0)}(t)$ and the predicted sequence $\hat{X}^{(0)}(t)$ can be expressed as:

$$\varepsilon^{(0)}(t+1) = -\alpha_\varepsilon\left(\varepsilon^{(0)}(t) - \frac{u_\varepsilon}{\alpha_\varepsilon}\right)e^{-\alpha_\varepsilon t} \tag{12}$$

where α_ε and u_ε represent the residual error sequence of the parameters α and u respectively. In the process of constructing the theoretical model of the residual error grey system, it is not necessary to modify all the numbers, only the number near the origin needs to be modified. The residual error model does not need all the residual errors, only the large values near the origin are used for modeling, then the modified prediction model of nitrogen pollution in ecological river area can be expressed as:

$$\hat{X}^{(0)}(t+1) = \left(X^{(0)}(1) - \frac{u}{\alpha}\right)e^{-\alpha t}\left(-\alpha_\varepsilon\right)\left(\varepsilon^{(0)}(t) - \frac{u_\varepsilon}{\alpha_\varepsilon}\right)e^{-\alpha_\varepsilon t} \tag{13}$$

The above formula can be used to predict the nitrogen pollution in ecological river, and to build a computer-aided model for preventing nitrogen pollution in ecological river.

Based on the above discussion, a grey correlation system theory was used to establish a prediction model for nitrogen pollution in ecological river. The original sequence was used to build the residual error sequence, and to build the residual grey system theory model, which optimized the ecological river nitrogen pollution prediction model, and realized the construction of the nitrogen pollution prevention computer-aided model.

3. Results

According to the water sample collection methods and requirements, combined with the specific conditions of the water sample collection area, the samples were collected in two ways: (1) In January, March, May, July, September and November of 2012–2014, one sample was collected in the same basin, a total of 18 samples were collected. (2) In 2014, one water sample was collected in 15 different types of waters of Shanzai Reservoir at the same time, a total of 15 samples were collected. During the sampling process, the name, location, coordinates, sampling time and other information of the sampling point were recorded in detail, and different measurement indicators of the same water sample were bottled separately. Some measurement indicators were pretreated on site, and then were transported back to the laboratory quickly.

3.1. Comparison of nitrogen pollution concentration at different times

Table 1 shows the nitrogen pollution concentration values obtained by the method in this paper in January to March, May, July, September, and November from 2012 to 2014. The comparison results are shown in Fig. 1.

Table 1
Nitrogen pollution concentration values in different months from 2012 to 2014

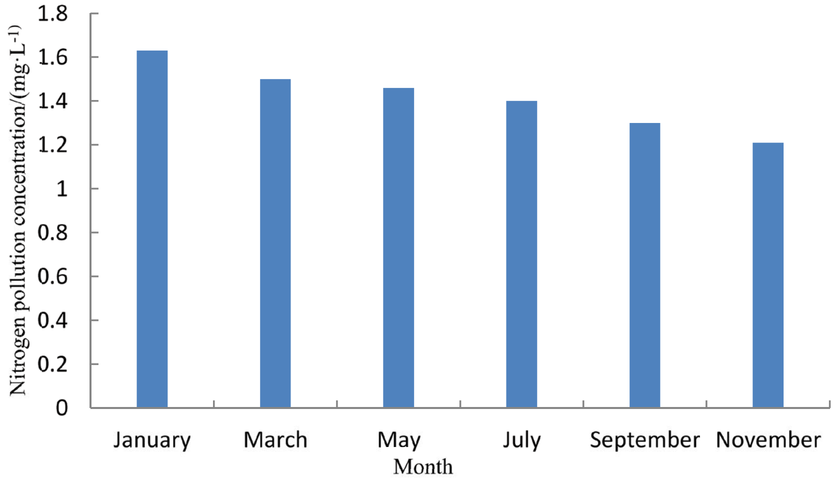
Year	Month	Nitrogen pollution concentration (mg L^{-1})
2012	January	1.63
	March	1.50
	May	1.46
	July	1.40
	September	1.30
	November	1.21
2013	January	1.60
	March	1.45
	May	1.40
	July	1.50
	September	1.21
	November	1.12
2014	January	1.70
	March	1.52
	May	1.63
	July	1.32
	September	1.30
	November	1.20

It can be seen from Table 1 that the nitrogen pollution concentration in November 2012 was 25.8% lower than that in January of the same year, and the nitrogen pollution concentration in November 2013 was 30% lower than that in January of the same year. The nitrogen pollution concentration in November 2014 was 29.4% lower than the value in January of the same year. The nitrogen pollution concentration value in July 2013 and May 2014 showed a slight rise and fluctuation. Combined with Fig. 1, it can be analyzed that the nitrogen pollution concentration values in 2012–2014 showed a gradually decreasing trend. The nitrogen pollution concentration values of all samples in March were higher than the values of the November sample. nitrogen pollution in the first half of the years is higher than that in the second half. The method in this paper can accurately analyze the nitrogen pollution concentration in the ecological river of Shanzi Reservoir at different times.

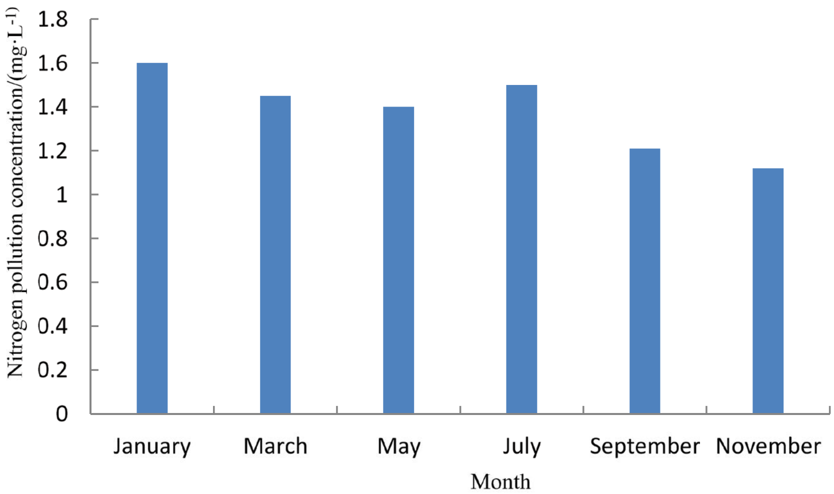
3.2. Comparison of nitrogen pollution in different regions

In order to further verify the accuracy of this method, the nitrogen pollution concentration in different water areas were compared and analyzed. Samples of 15 different water areas were numbered 1 to 15, as shown in Table 2.

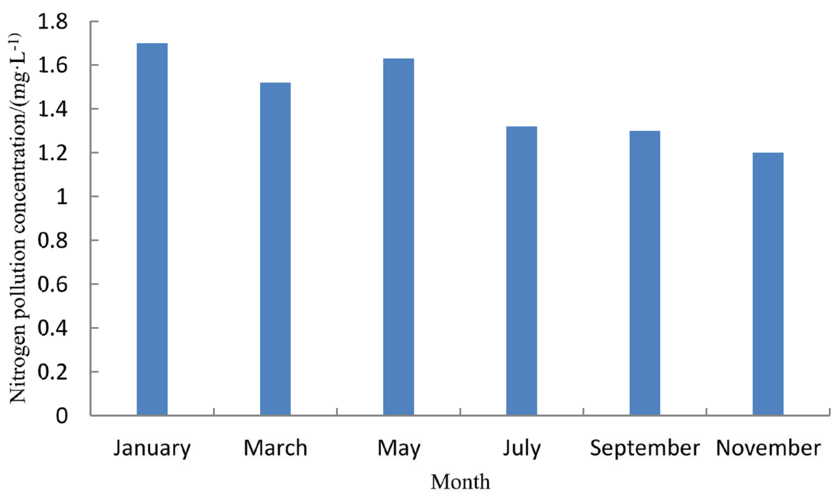
It can be seen from Table 2 that the nitrogen pollution concentration values in different water areas are different, and there is no fixed trend. The method in this paper can accurately reflect the nitrogen pollution status in each water area and provide a favorable basis for the water quality management of Shanzi Reservoir. At the same time, the analysis accuracy of the method in this paper is further verified.



(a)



(b)



(c)

Fig. 1. Comparison of nitrogen pollution concentration values in each month from 2012 to 2014.

3.3. Water quality index in different regions

The specified method was used to analyze the water quality indexes of 15 different water samples in the study area, and total nitrogen, ammonia nitrogen, total phosphorus, chemical oxygen demand, permanganate index, nitrate nitrogen, Cd, Cr(VI), Zn, Pb, Cu were selected to perform principal component analysis. The data results are shown in Table 3.

Table 2
Comparison of nitrogen pollution concentration values in different water areas

Different water area sample numbers	Nitrogen pollution concentration (mg L^{-1})
1	1.23
2	1.05
3	1.34
4	1.11
5	1.20
6	0.98
7	1.01
8	1.30
9	1.24
10	1.08
11	1.19
12	1.02
13	1.33
14	1.16
15	1.41

Table 3 shows the water quality index of different water areas. Based on this index, the water quality of the study area can be analyzed and provide data to deal with the pollution of ecological rivers properly.

3.4. Comparison of analysis performance of different methods

In order to verify the analysis efficiency and accuracy of the method in this paper, a model method based on a wavelet neural network and an improved BP neural network model method were used to perform a comparative experiment. During the experiment, Intel Core i5 3.0GHz CPU was used as the hardware condition, and MATLAB software was used to simulate the experiment process. The results of the experiment are as follows.

3.4.1. Comparison of time consumption

The nitrogen pollution status in different areas was analyzed, and the analysis time (min) consumption of nitrogen pollution status under different methods was compared. The experimental results are shown in Table 4.

It can be seen from Table 4 that the nitrogen pollution condition based on the wavelet neural network model method takes the longest time, using a time of 2.99–3.57 min, and its efficiency is low. The nitrogen pollution status based on the improved BP neural network model is centered, using time of 2.88–3.44 min, and its overall time-consuming basis is long, and the efficiency is not ideal. The analysis time of the method in this paper is lower than the other two methods. The time consumption is 1.89–2.45 min, and the average time consumption in 15 predictions is only 2.145 min. It shows that the method of this paper is fast in analyzing nitrogen pollution and the analysis efficiency is ideal.

Table 3
Standardized treatment data of water quality index of Shanzai Reservoir ecological river

Different water area sample numbers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total nitrogen (mg L^{-1})	1.23	1.05	1.34	1.11	1.20	0.98	1.01	1.30	1.24	1.08	1.19	1.02	1.33	1.16	1.41
Ammonia nitrogen (mg L^{-1})	0.10	0.04	0.40	0.23	0.06	0.35	0.26	0.60	0.35	1.14	0.30	0.21	0.10	0.16	0.07
Total phosphorus (mg L^{-1})	–0.47	–0.70	0.55	2.15	0.55	–0.23	–0.11	0.02	–0.35	–0.82	–1.12	–0.58	0.67	1.74	–0.76
Chemical oxygen demand (mg L^{-1})	–0.52	–1.22	–1.53	–0.20	1.67	–0.15	–0.32	0.27	1.48	0.34	1.15	–0.65	0.86	–0.19	–0.15
Permanganate index (mg L^{-1})	1.30	–0.45	–0.13	0.41	–0.20	–1.51	0.10	–0.22	0.13	–0.19	–1.06	–1.13	1.74	1.79	–0.25
Nitrate nitrogen (mg L^{-1})	–0.43	0.04	0.39	1.28	–0.12	–0.23	–1.02	–0.68	–0.66	–0.55	–0.82	1.07	–0.14	2.63	–0.68
Cd (mg L^{-1})	–0.23	–0.38	–0.17	–0.18	3.61	–0.25	–0.21	–0.29	–1.03	–0.18	–0.03	–0.16	–0.18	–0.11	1.01
Cr(VI) (mg L^{-1})	–0.86	–2.44	–0.52	–1.09	–0.40	–0.86	–0.63	0.15	0.19	1.26	1.21	0.87	0.04	0.64	0.98
Zn (mg L^{-1})	–0.14	–0.41	–0.50	–0.49	–0.47	–0.18	2.55	–0.44	0.06	–0.48	2.20	0.16	–0.21	–0.27	–0.42
Pb (mg L^{-1})	–0.11	–1.15	–0.17	–0.36	–0.49	0.72	0.36	1.49	–0.49	–0.19	1.27	1.83	–0.32	–0.11	–0.38
Cu (mg L^{-1})	–0.26	–0.34	–0.28	–0.27	2.42	2.48	–0.26	–0.33	–0.23	–0.15	–0.22	–0.25	1.05	–0.39	–0.28

3.4.2. Accuracy comparison

Comparing the analysis accuracy of the three methods, as shown in Table 5, and the analysis accuracy and its trend are shown in Fig. 2.

According to Table 5, it can be concluded that the wavelet neural network-based model has the lowest accuracy in analyzing nitrogen pollution among the three methods. The accuracy range is 79.8% to 89.1%, and the average analysis accuracy is 83.6%. The analysis accuracy range based on the improved BP neural network model is 83.9% ~ 94.3%, and the average analysis accuracy is 92.4%. The analysis accuracy range of the method in this paper is 95.4% ~ 98.7%, and its average analysis accuracy can reach 97.8%. It shows that the method in this paper has the highest accuracy in analyzing nitrogen pollution.

It can be seen from Fig. 2 that the analysis accuracy of the three methods has fluctuations, but the analysis accuracy of the method in this paper has small fluctuations and is always in a stable state. The other two methods show different degrees of fluctuation. The stability of the method in this paper is good.

4. Discussion

The status of Shanzi Reservoir ecological river is affected by various factors. The distribution and structure of nitrogen pollution have an impact on eutrophication in the reservoir

Table 4
Comparison of nitrogen pollution conditions in ecological river waters using different methods

Different water area sample numbers	Article method (min)	Model method based on wavelet neural network (min)	Based on improved BP neural network model (min)
1	2.04	3.13	2.94
2	1.98	3.01	2.98
3	2.12	3.20	3.06
4	2.45	3.51	3.38
5	2.30	3.37	3.26
6	2.17	3.24	3.15
7	1.90	2.99	2.69
8	2.25	3.41	3.18
9	1.89	3.33	3.01
10	2.05	3.57	3.44
11	2.19	3.46	2.97
12	2.41	3.38	3.16
13	2.22	3.19	2.88
14	2.11	3.26	3.25
15	2.08	3.35	3.16

Table 5
Comparison of analysis accuracy values of different methods

Different water area sample numbers	Article method (%)	Model method based on wavelet neural network (%)	Based on improved BP neural network model (%)
1	97.5	85.1	89.7
2	98.0	83.4	90.2
3	98.3	88.0	90.8
4	97.1	81.3	88.7
5	98.7	80.2	83.9
6	96.9	82.9	91.3
7	95.4	83.5	90.5
8	97.8	84.1	92.4
9	98.2	83.6	91.8
10	96.7	81.8	93.1
11	97.6	87.6	93.5
12	98.2	89.1	94.3
13	97.9	80.5	91.7
14	98.3	81.1	90.9
15	96.9	79.8	84.8

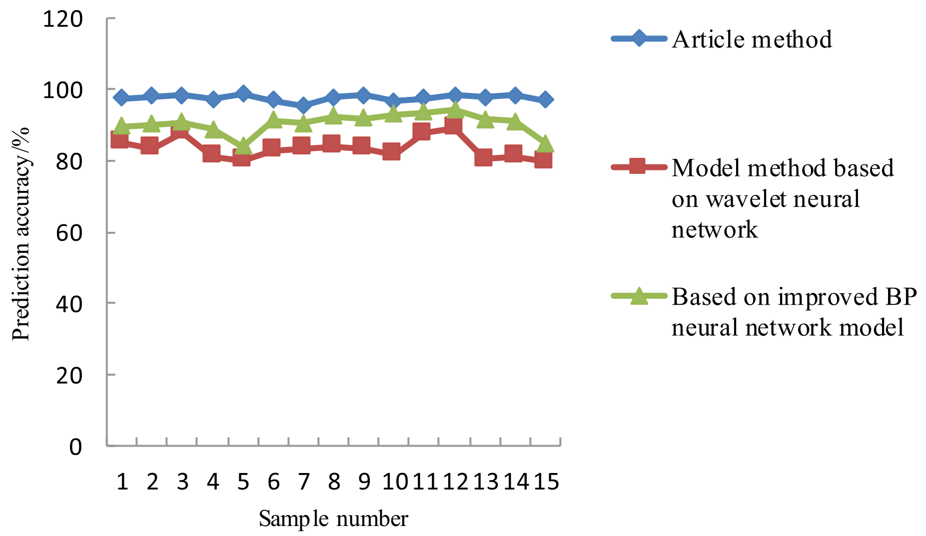


Fig. 2. Analysis accuracy and change trend of different methods.

area. The nitrogen pollution in the Shanzai Reservoir shows special spatial differentiation and structured characteristics, and it is closely related to the water quality zoning. The townships Hukou and Rixi, which are close to the reservoir, are the most polluted. The discharge of manure from livestock and poultry breeding in these areas, and the unreasonable fertilization methods during agricultural production, are the main factors that increase nitrogen content. A large amount of nitrogen nutrients passing through Hukouxi, Huang Didongxi and Rixi directly enter the reservoir, which had a decisive impact on the water quality of the reservoir [23]. The nitrogen concentrations in the water surface are obviously divided into zones. The high nitrogen in Rixi inlet bay is mainly affected by river input. The dam exhibits high nitrogen distribution, which may be related to the release of inorganic nitrogen from the sediments, and may also be related to the nitrogen emissions caused by the cultivation of orchards in the reservoir area. (Although the pollution load around reservoir area is small, it can directly enter the reservoir and affect the local water quality). The sources of the nitrogen in the basin are basically the same, such as the livestock and poultry farming, domestic sewage and fertilizer loss [24]. Due to the different nitrogen emission coefficients of different sources, the pollution structure of the basin (the relative proportion of the three anthropogenic sources of pollution) will ultimately affect the nitrogen concentrations in water. The nitrogen ratio in the water basically corresponds to the pollution structure and spatial distribution of the basin [25]. Nitrogen is present in rivers in the form of dissolution. Rainfall, soil, vegetation and river slope, and dam interception all affect the nitrogen migration and transformation process, which presents significant spatio-temporal change [26]. After entering the reservoir area, nitrogen is affected by the river topography, biological absorption, and internal circulation. So the nitrogen ratio in the water changes dynamically, which corresponds to the standard deviation of the nitrogen ratio in the water is large [27].

Obviously, changes in water quality and ecosystem succession in Shanzi Reservoir area are directly related to man-made pollution in the basin. It should be noted that the primary production of the Shanzai Reservoir ecosystem is generally limited by nitrogen. Under the continuous input of external nitrogen and endogenous circulation (release of sediment), the nitrogen content in the water is rich, and the water in the reservoir is in a still condition. These can easily cause the blooming phenomenon, and the ecological risk is relatively high. Therefore, a comprehensive prevention and control strategy for nitrogen pollution and eutrophication is proposed to address this issue, as follows:

Based on the overall goal of water quality improvement and ecological restoration in Shanzi Reservoir area, a comprehensive prevention and control strategy for nitrogen pollution and eutrophication in the reservoir area is proposed:

- Governance of basin pollution by areas and items. Upstream villages and towns should focus on controlling domestic pollution, and rural domestic sewage land treatment technology can be implemented. There are a large number of pig farms in Rixi, Hukou, Yanping, and Shanyang, and a lot of poultry farming in Xiazhu and Dajia. They should be strictly forbidden to expand or build new ones. Existing farms must be strengthened to treat manure (such as composting and returning to the field). Farms around the reservoir should be demolished and strictly monitored for reconstruction. Huokouxi, Rixi Valley, and sloping land around the reservoir should focus on controlling water and soil loss and fertilizer loss.
- Nitrogen removal and ecological restoration. Nitrogen released from sediments at the entrance of the Rixi and the dam affects the eutrophication of the water. Measures such as timely dredging, and ecological dispatch can be used to reduce the storage of nutrients. The water quality at the entrance of Rixi and HuangDidongxi is poor. Aquatic plants can be planted, ecological floating islands can be set up, or herbivorous and filter-feeding fish can be properly introduced for ecological restoration.
- Joint reduction of nitrogen. There are different key sources of nitrogen pollution, and a joint control plan

for nitrogen pollution should be made at the basin level [28] to comprehensively improve water quality. With the socio-economic development and the adjustment of agricultural structure, from the perspective of reducing the water bloom, priority should be given to controlling nitrogen-rich livestock and poultry breeding and nitrogen fertilizer loss. The Rixi, Huang Didongxi and Huokouxi situated in middle and lower reaches of the reservoir is the key governance area [29].

- Control of sediment nitrogen content. Effective measures should be taken to reduce nitrogen content in sediment. At present, there are two main methods adopted internationally. One is to grow aquatic plants, and the other is sediment dredging. The most important thing is that the local government and residents do a good job of water quality protection and pollution source control, and fundamentally eliminate pollution before treatment [3].

5. Conclusion

Nitrogen pollution in ecological river adversely affects economic development and human health. In order to prevent and treat nitrogen pollution in ecological river in time, this paper builds a prediction model for nitrogen pollution based on computer-aided analysis. Through the model, the situation of nitrogen pollution in ecological river area is analyzed, which provides a basis for the prevention and control of nitrogen pollution in ecological water area. The results verify that this method can effectively analyze the nitrogen pollution, and the analysis results are accuracy, high efficiency and good stability.

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