Study on water environment simulation and prediction in Sanhekou Reservoir area

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**Abstract:** Sanhekou Reservoir is an important water source of the Hanjiang to Weihe River Project in Shanxi Province. In order to simulate and predict the health status of the reservoir ecological environment, sensitivity analysis of related parameters was carried out based on AQUATOX model, and the key parameters were determined. The main water quality indexes and the change rule of algae in Sanhekou Reservoir were simulated.The water quality and ecological process of the reservoir are predicted. The important parameters, such as ,the optimum temperature corresponding to Phyt, Blue-Green max and Phyt Low-Nut Diatom , Including the maximum photosynthetic rate of Phyt, Blue-Green max et al,was determined. The simulation results are good. The average relative errors are within 15%. The total phosphorus (TP) concentration in 2020 is below 0.029 mg∙L-1, the total nitrogen (TN) concentration is below 0.68 mg∙L-1, and the water quality is between Class Ⅱ and Class Ⅲ. The biomass of Phyt High-Nut Diatom, Phyt Low-Nut Diatom, Phyto, Green and Phyt, Blue-Green max had obvious seasonal variation, which was roughly consistent with the actual water environment of Sanhekou Reservoir.The results show that the water quality of Sanhekou reservoir will remain between Class Ⅱ and Class Ⅲ, and the water quality in the dry season is the best period of each year. Phyt, Blue-Green max have the largest biomass, with a peak of 1.25~1.45 mg∙L-1 (dry weight).The simulation study can provide guidance for water ecological control and management of Sanhekou reservoir in the future.

**Key words:** AQUATOX model; water quality; the algae; sanhekou reservoir; water environment

With the development of water resources, the pollution of natural lakes and the degradation of ecosystem are becoming more and more serious. As an important storage facility built by man, the reservoir will play a pivotal role in the future water supply system[1]. Therefore, China has always attached great importance to the scientific management and development of reservoir. Sanhekou Reservoir in Shaanxi Province is a typical watercourse reservoir, which is an important water source for the Hanjiang to Weihe River diversion project. It is of great practical significance for people's health to ensure the water quality and water ecological environment in the water source area. Therefore, it is very important to accurately evaluate, analyze and predict the water ecological environment in the reservoir area. Water ecological simulation technology is an important means to study water ecological problems. It can be used to simulate water eutrophication, water quality assessment and the changes of biological communities in water areas, and provide important guidance for water ecological assessment and management.[2]

At present, the research methods of reservoir water environment at home and abroad can be divided into two categories: one is to obtain relevant data directly through field measurement; The other is to conduct scientific research on reservoir water environment through numerical model. It is difficult and uneconomical to study water environment condition through field measurement, but numerical simulation method can overcome the limitation of field measurement and has strong practicability. In recent years, water ecological simulation technology has been widely used in reservoir eutrophication control research and reservoir ecosystem construction and management, which provides strong theoretical support for the development of practical projects[3~4]. AQUATOX model is a relatively comprehensive water ecosystem model, which can simulate and study the past, present and future water ecosystem conditions and carry out risk assessment[5]. S. Çevirgen et al. constructed the steady-state model of Venice Lagoon with the AQUATOX model, predicted the interaction between the main variables, and further proposed two management schemes[6]. Irene Martins et al. used the AQUATOX model to analyze the responses of single or combined changes of air temperature, rainfall and river discharge in Minho estuary to changes in macroinvertebrate biomass[7].

At present, there are few studies on the water ecological environment of Sanhekou Reservoir. This study takes Sanhekou reservoir as the study area and uses water quality indicators and algal biomass to build an AQUATOX model suitable for this reservoir. The sensitivity analysis function of AQUATOX model is used to analyze the key parameters, and the key parameters that have a great impact on the model results are obtained, so as to make the parameter calibration more scientific and effective, and make the model more reasonable and scientific[8]. The measured data were used to verify the model, and error analysis was conducted to predict the water quality indicators and algae biomass in the reservoir area from 2021 to 2023, and then analyze the evolution of the water ecosystem in the Sanhekou reservoir area, so as to provide guidance for ecological risk assessment and related research in the reservoir area[9].

# 1. Overview of the research area

The Hanjiang to Weihe River Project is a large-scale cross-basin water diversion project to alleviate the shortage of water in Guanzhong area of Shaanxi Province. Sanhekou Reservoir is an important water source of the Hanji-Wei River diversion project. The reservoir is mainly located at the confluence of Jiaoxi River, Puhe River and Wenshui River, three tributaries of Ziwu River, and is a typical river channel reservoir. The dam site of Sanhekou water conservancy project is located in the gorge section of Ziwu River, a tributary of Han River, at the junction of Foping County and Ningshan County, Hanzhong City, 2km downstream of Sanhekou Village, Foping County, belongs to the middle of the Qinling Mountains and north of the Han River. The terrain is high in the north and low in the south. The main task is to regulate and store the incoming water from Ziwu River in the basin and the water from the main stream of Han River that is transferred to the storage through the pumping station. The maximum dam height is 145 meters, the normal water level elevation of the reservoir is 643m, the total storage capacity is 710 million cubic meters, the adjusted storage capacity is 660 million cubic meters, and the controlled watershed area above the dam site is 2186km2.



Fig. 1 Geographical location of Sanhekou Reservoir

# 2. Materials and Methods

## 2.1 Data Sources

In this study, six samples were collected from 10 sampling sites in the Sanhekou Reservoir area from July to December 2019. The characteristic parameters of water quality were water temperature (T), pH, total nitrogen (TN), total phosphorus (TP), dissolved oxygen (DO), chemical oxygen demand (COD), ammonia nitrogen (NH3-N), etc. Among them, T, DO and pH were measured by portable water quality detector (HACH-DS5, USA). Three samples were collected from each sampling point, placed in an ice box, and brought back to the laboratory for testing. TP data were obtained using total phosphorus analyzer, and TN was determined according to the requirements of "Determination of total Nitrogen in Water Quality by alkaline potassium persulfate Digestion UV spectrophotometry" (HJ 636-2012)[10]. The determination of NH3-N was based on the "determination of water quality ammonia nitrogen" Nath reagent spectrophotometric method (HJ 535-2009)[11], and the determination of COD was based on the "determination of water chemical oxygen demand dichromate method" (HJ 828-2017)[12], and the determination of algae is based on the Technical Specification for the Detection of planktonic algae in Freshwater (DB32/T4005-2021)[13]. The main hydrological characteristics of Sanhekou Reservoir are shown in Table 1, and the main algae and their parameters are shown in Table 2.

Table 1 Main hydrological characteristics of Sanhekou Reservoir

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Water area /km2 | The maximum length /km | The average water depth /m | Maximum depth of the water/m | Mean evaporation /(in∙a-1) | The average temperature /℃ | The average light intensity /(ly∙d-1) |
| 16.04 | 10 | 44.3 | 84 | 23.19 | 12.3 | 269.33 |

Table 2 Main algae and their parameters in Sanhekou Reservoir

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Species | Phyt High-Nut Diatom | Phyt Low Nut Diatom | Phyto,Green | Phyt,Blue-Green |
| B0 | 0.5 | 0.5 | 1 | 0.01 |
| *LP* /(mg∙L-1) | 0.06 | 0 | 0.1 | 0.03 |
| *LN* /( mg∙L-1) | 0.12 | 0.02 | 0.8 | 1.2 |
| *T* /℃ | 20 | 26 | 26 | 30 |
| *VP* /(d-1) | 1.87 | 1.4 | 1.65 | 3.9 |
| *SL* /(ly∙d-1) | 22.5 | 56 | 110 | 150 |

In Table 2, B0 represents the initial biomass and represents the case of planktonic algae (high trophic diatoms, low trophic diatoms, green algae and cyanobacteria), in mg∙L-1; LP is phosphorus half-saturation parameter; LN is the nitrogen half-saturation parameter; T is the optimal temperature; VP is the maximum photosynthetic rate. SL is the optical saturation.

## 2.2 Model Establishment

AQUATOX model is a comprehensive model of water ecosystem proposed by EPA in 2005. It is used to simulate the impact of multiple factors (such as physical, chemical, biological, etc.) on water ecosystem and conduct risk assessment[14~15]. The model has complete parameter database data, including five parameter libraries: plant bank, mineralization bank, animal bank, chemical material bank and site bank, which can provide parameters for most of the lake and reservoir ecosystem simulation[16].

In this model, algae is represented by its biomass in the water body, and the unit of planktonic algae is g m-3. The main calculation equation is as follows:

$\frac{dBio\_{Phy}}{dt} =S\_{l}+V\_{pho}+S\_{res}+S\_{exc}-S\_{mor}-S\_{pre}\pm S\_{sin}\pm S\_{flo}-S\_{out}+S\_{in}\pm S\_{tur}\pm S\_{seg}+\frac{S\_{slo}}{3}$ （1）

Where, *dBiophy/dt* is the change value of planktonic algae biomass with time, g∙(m3.d)-1; *Sl* is the critical value of algal biomass, g∙(m3.d)-1; *Vpho* is the rate of photosynthesis of algae, g∙(m3.d)-1; *Sres* is the loss of respiration, g∙(m3.d)-1; *Sexc* is loss of excretion or photorespiration, g∙(m3.d)-1; *Smor* is the number of non-predation deaths, g∙(m3.d)-1; *Spre* is the number of predation deaths, g∙(m3.d)-1; *Ssin* refers to the increase or decrease of algal biomass caused by material exchange between water and bottom sediment, g∙(m3.d)-1; *Sflo* is the biomass loss of deep water and the biomass increase of upper water caused by floating phytoplankton due to buoyancy, g∙(m3.d)-1; *Sout* is the amount of loss carried by the current into the downstream, g∙(m3.d)-1; *Sin* is the amount of increase carried by upstream flow entry, g∙(m3.d)-1; *Stur* is the increase or decrease of biomass caused by turbulent diffusion, g∙(m3.d)-1; *Sseg* is the biomass change caused by the diffusion and transmission at the junction of the two parts of the water, which is g∙(m3.d)-1; *Sslo* represents the amount of loss of attached algae washed by water flow, g∙(m3.d)-1.

AQUATOX can simulate the cycling process of nutrients in water, including nitrogen, phosphorus, debris, oxygen and carbon simulation. Taking ammonia nitrogen as an example, its simulation equation can be expressed as follows:

$\frac{dam}{dt}=N\_{l}+N\_{rem}+N\_{nit}-N\_{ass}-N\_{out}+N\_{in}\pm D\_{tur}\pm N\_{dif}+D\_{flu}$ （2）

In Equation (2), *dam/dt* represents the change value of ammonia nitrogen with time, g∙(m3.d)-1; *Nl* denotes nutrient load from upstream, g∙(m3.d)-1; *Nrem* is ammonia from organisms and detritus, g∙(m3.d)-1; *Nnit* is the ammonia nitrogen transformed by nitrification, g∙(m3.d)-1; *Nass* is the ammonia nitrogen absorbed by plants, g∙(m3.d)-1; *Nout* is the ammonia nitrogen lost by flowing into the downstream water body, g∙(m3.d)-1; *Nin* is the ammonia nitrogen carried by the upstream flowing into the water body, g∙(m3.d)-1; *Dtur* is the deep turbulent diffusion between the upper and lower layers of stratified water body, g∙(m3.d)-1; *Ndif* is the increase or loss caused by diffusion transport at the junction of two parts of water body, g∙(m3.d)-1; *Dflu* is the potential flux from the sediment diagenetic model, g∙(m3.d)-1.

## 2.3 Parameter sensitivity analysis

In order to understand the different degrees of influence of each parameter variable on the model output results, parameter calibration can be carried out more scientifically and sensitivity analysis can be carried out. The sensitivity calculation equation is as follows:

$Sen=\frac{|Res\_{pos}-Res\_{base}|+|Res\_{neg}-Res\_{base}|}{2∙|Res\_{base}|}∙\frac{100}{changed}$ （3）

Where, *Sen* is the normalized sensitivity statistic, (%);*Respos*, *Resneg* and *Resbase* are the average results (baseline) of a given endpoint with positive, negative or no change in the input parameters; Changed is the percentage of the input parameter changed in the positive or negative direction.

In this study, we chose to increase or decrease the test parameters of algae by 10%. Excessive parameter variation may exceed the reasonable value and give misleading results. Through the analysis of the output results, to determine the input parameters that have a great impact on the output results, can be more reasonable to calibrate the parameters, adjust the model, so that the output results more scientific.

# 3. Results and analysis

## 3.1 Parameter calibration

### *3.1.1 Parameter sensitivity analysis of Phyt High-Nut Diatom*

The biomass of Phyt High-Nut Diatom was the most sensitive to the death index coefficient with 10% change (79.5%), followed by the optimum temperature (58.2%) and the maximum photosynthetic rate (19.6%).The sensitivity of nitro-nitrogen to Phyt High-Nut Diatom parameters is generally not high, among which the highest sensitivity is the sensitivity to extinction coefficient, but the sensitivity is only 10.8%; Phyt High-Nut Diatom parameters have little effect on total dissolved phosphorus, and the sensitivity of total dissolved phosphorus to the saturated luminosity of Phyt High-Nut Diatom is the largest, which is only 9.93%.These results indicate that Phyt High-Nut Diatom parameters have a certain effect on Phyt High-Nut Diatom biomass, but have little effect on nitrate and total dissolved phosphorus.

### *3.1.2 Phyt Low-Nut Diatom*

The sensitivity of Phyt Low-Nut Diatom biomass to mortality index coefficient was 78.2%, and the sensitivity to optimum temperature, maximum photosynthetic rate and saturation light were 56.7%, 24.3% and 19.3%, respectively. The sensitivity of nitrate to the parameters of Phyt Low-Nut Diatom was not very high, and the sensitivity to the optimum temperature of Phyt Low-Nut Diatom was only 5.01%, and the sensitivity to the maximum photosynthetic rate of Phyt Low-Nut Diatom was 2.45%. The sensitivity to other parameters was less than 2%; The sensitivity of total dissolved P to Phyt Low-Nut Diatom parameters was generally not very high. The sensitivity of total dissolved P to the optimum temperature of Phyt Low-Nut Diatom was only 12.95%, the sensitivity of total dissolved P to the maximum photosynthetic rate was 10.35%, and the sensitivity of other parameters was less than 10%. In conclusion, Phyt Low-Nut Diatom parameters have a certain effect on the biomass of Phyt Low-Nut Diatom, but have little effect on nitrate and total dissolved phosphorus.

### *3.1.3 Parameter sensitivity analysis of PhHyto，Green*

The biomass of Phyto,Green had the highest sensitivity to the mortality index coefficient (65.6%), the sensitivity to the optimum temperature was 9.8%, and the sensitivity to other parameters was low. The sensitivity of nitrate nitrogen and total dissolved phosphorus to Phyto,Green parameters was less than 10%. Therefore, the influence of Phyto,Green parameters on nitrate and total dissolved phosphorus is not very great.

### *3.1.4 Parameter sensitivity analysis of Phyt，Blue-Green max*

The sensitivity of Phyt，Blue-Green max biomass to cyanobacterial parameters was relatively large, and the sensitivity to optimal temperature was the highest, reaching 1718%. The sensitivities to maximum photosynthetic rate, death index coefficient, phosphorus half-saturation parameter, maximum temperature, extinction coefficient and minimum temperature were 367%, 306%, 265%, 106%, 85.7% and 84%, respectively. The sensitivity of nitrate to the optimum temperature reached 10.8%, and the sensitivity to the maximum photosynthetic rate and extinction coefficient were 4.62% and 3.04%, respectively. The sensitivity of total dissolved phosphorus to Phyt，Blue-Green max parameters was not very high, and the sensitivity to the optimum temperature was only 4.05%. It can be seen that Phyt，Blue-Green max parameters have a relatively large impact on Phyt，Blue-Green max biomass, but not on nitrate and total dissolved phosphorus.

While the model itself contains related biological parameters, but due to the actual situation of simulation area difference, the parameters of the model with don't accord with the actual situation of simulation area, so need to calibration parameters by parameter calibration, choose the more suitable for the parameters of the simulation area actual situation, making the simulation more realistic and scientific. In this paper, ten parameters that are most likely to be changed are selected, Sensitivity analysis was conducted using AQUATOX model to analyze the sensitivity of parameters of Phyt High-Nut Diatom, Phyt Low-Nut Diatom, PhHyto，Green and Phyt，Blue-Green max, so as to determine the key parameters that have the greatest impact on the model. The parameter rate must consult the relevant data first, determine the initial value and variation range of the parameter, and then through continuous trial calculation and comparison, select the most suitable parameter value for the actual situation of Sanhekou reservoir. Based on the results of sensitivity analysis, the key parameters that have great influence on the model are calibrated in this paper. The calibration results are shown in Table 3.

Table 3 Model calibration results

|  |  |  |
| --- | --- | --- |
| Model parameters | Calibration results | Unit |
| Optimal Temperature(Phyt，Blue-Green max)Optimal Temperature(Phyt Low-Nut Diatom)Optimal Temperature(Phyt High-Nut Diatom)Max.Photosynthetic.Rate(Phyt，Blue-Green max)Exponential Mort coefficient (Phyt，Blue-Green max)P Half-Saturation(Phyt，Blue-Green max)Maximum Temperature(Phyt，Blue-Green max)Light Extinction(Phyt，Blue-Green max)Exponential Mort coefficient (Phyt High-Nut Diatom)Exponential Mort coefficient (Phyt Low-Nut Diatom)Exponential Mort coefficient (PhHyto，Green)Min Adaptation Temperature(Phyt，Blue-Green max) | 2825223.80.110.02949.20.150.050.050.045.6 | ℃℃℃d-1—mg∙L-1℃m-1———℃ |

## 3.2 Verification and analysis

After the model parameters were calibrated, the measured data in January, March, May, July, September and November 2020 were used to verify the AQUATOX model after parameter calibration. Water quality indexes (TP, TN, NH3-N, NO3) and algae biomass (Phyt High-Nut Diatom, Phyt Low-Nut Diatom, PhHyto，Green, Phyt，Blue-Green max) of Sanhekou Reservoir were used as the main validation objects and compared with the measured values. A total of 10 sampling points are arranged in the reservoir area, and the monthly measured data is the average value of 10 samples per month.

The comparison of simulated results of water quality index and algae biomass with measured values is shown in Figure 2 and Figure 3, respectively. The mean absolute error and mean relative error are used to analyze the verification results, and the results are shown in Table 4. From the error analysis results, TP, NH3-N, NO3, PhHyto，Green and Phyt，Blue-Green max simulation results are good, the average relative error is less than 10%; The mean relative errors of TN, high nutrient diatom and low nutrient diatom were all within 15%. The simulation results can reflect the change law of water environment in Sanhekou reservoir better, and we can judge that the model parameters are reasonably corrected and the simulation results are credible.

Table 4 Error analysis of simulated and measured values

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| project | TP | TN | NH3-N | NO3 | Phyt High-Nut Diatom | Phyt Low-Nut Diatom | PhHyto，Green | Phyt，Blue-Green max |
| Mean absolute error | 0.0013 | 0.05 | 0.0017 | 0.0155 | 0.00013 | 0.0029 | 0.0022 | 0.045 |
| Mean relative error | 5.39% | 10.73% | 5.90% | 4.52% | 11.08% | 12.52% | 7.78% | 7.98% |



a- TP b- TN



c- NH3-N d- NO3

Simulation value

The measured values

Fig. 2 Comparison between simulated results and measured values of water quality indexes

It can be seen from Figure 2 that the total phosphorus (TP) concentration ranged from 0.015 to 0.029 mg∙L-1, and gradually increased from January to May, reaching the peak value of about 0.029 mg∙L-1 in late May, and then the concentration showed a downward trend with time. The total nitrogen (TN) concentration ranged from 0.25 to 0.68 mg∙L-1, and the total phosphorus concentration gradually increased from January to August, and reached the peak value of 0.66 mg∙L-1 in August, and then decreased continuously. The concentration of ammonia nitrogen (NH3-N) ranged from 0.018 to 0.04 mg∙L-1, fluctuated around 0.021 mg∙L-1 from January to March, gradually increased from April to June, fluctuated around 0.038 mg∙L-1 from July to September, and decreased continuously after late September. The concentration of nitrate nitrogen (NO3) ranged from 0.18 to 0.5 mg∙L-1, and gradually increased from January to July. The concentration peaked from July to September, and reached a peak of about 0.5 mg∙L-1 in August. The concentration was stable in October, and then decreased continuously until it fell to about 0.3 mg∙L-1 in December. According to the "Surface Water Environmental Quality Standards" (GB3838-2002)[17], the water quality was evaluated by single factor index method, and the water quality in the study area in 2020 was classified as class Ⅱ and class Ⅲ. In the wet season, the nutrient concentration is higher, with the arrival of dry season, the nutrient concentration will decrease, the water quality is better.



a- Phyt High-Nut Diatom b- Phyt Low-Nut Diatom

 

c- PhHyto，Green d- Phyt，Blue-Green max

Simulation value

The measured values

Fig.3 Comparison between simulated results and measured values of algae

As can be seen from Figure 3, the biomass of Phyt High-Nut Diatom and Phyt Low-Nut Diatom increased first and then decreased with time. The peak growth period was from August to September, and the biomass of Phyt High-Nut Diatom reached about 2.2×10-3 mg∙L-1 (dry weight) in August. Phyt Low-Nut Diatom biomass peaked at around 0.05 mg∙L-1 (dry weight) in early September. The biomass of PhHyto，Green and Phyt，Blue-Green max increased first, reached the peak, then fluctuated steadily, and then decreased. The peak biomass of PhHyto，Green was about 0.052 mg∙L-1 (dry weight) from July to September. The bloom period of Phyt，Blue-Green max was from May to August, and the peak biomass was about 1.1 mg∙L-1 (dry weight). It can be seen from the above that algae have obvious seasonal changes. With the increase of temperature, algae will usher in a flourishing period. After September, as the temperature decreases, the biomass will decrease.

## 3.3 Forecast and analysis

AQUATOX model based on pass by parameter calibration and verification, forecast in January 2021 to December 2023 in the Sanhekou reservoir water quality index（TN、NH3-N、NO3、TP） and algae (Phyt High-Nut Diatom、Phyt Low-Nut Diatom、PhHyto，Green、Phyt，Blue-Green max) biomass (as shown in figure 4 and figure 5), and analyze the Sanhekou reservoir in the prediction period of the status of the water ecological system.



a-TP b-TN



c-NH3-N d-NO3

Fig.4 Prediction results of water quality indexes

It can be seen from Figure 4 that during the forecast period, the contents of total phosphorus (TP), total nitrogen (TN), ammonia nitrogen (NH3-N) and nitrate nitrogen (NO3) all show an overall upward trend with a small increase. The concentration of total phosphorus ranged from 0.016 to 0.036 mg∙L-1, and the concentration was higher in April to September, with the peak value ranging from 0.03 to 0.036 mg∙L-1. The concentration of total nitrogen ranged from 0.29 to 0.72 mg∙L-1, and the concentration of total nitrogen was higher in June to September, and the peak value was between 0.68 and 0.73 mg∙L-1. The concentration of ammonia nitrogen ranged from 0.019 to 0.047 mg∙L-1, and the concentration was higher in June to September, with the peak value between 0.030 to 0.047 mg∙L-1. The concentration of nitrate ranged from 0.30 to 0.60 mg∙L-1, and the content was higher in July to September, and the peak value was between 0.048 and 0.060 mg∙L-1. It can be seen from the above that the water quality indexes show obvious seasonal changes, which is basically consistent with the simulated situation in 2020. In the wet season, the nutrient concentration is higher, and in the dry season, the nutrient concentration is at a lower value, and the water quality in this period is the best in a year. The concentration of each nutrient has a trend of increasing year by year, but the range is small, which is still lower than the class Ⅲ water standard of "Surface Water Environmental Quality Standard" (GB3838-2002). During the prediction period, the water quality in the study area will be between class Ⅱ and class Ⅲ.

 

a- Phyt High-Nut Diatom b- Phyt Low-Nut Diatom



c- PhHyto，Green d- Phyt，Blue-Green max

Fig.5 Prediction results of algae biomass

According to Figure 5, the biomass of Phyt High-Nut Diatom is small, and the peak growth period is between August and September each year, and the peak range is between 1.4×10-3 ~ 2×10-3 mg∙L-1 (dry weight). The growth period of Phyt Low-Nut Diatom was also in August to September each year, and the peak value ranged from 0.03 to 0.045 mg∙L-1 (dry weight). The biomass of PhHyto，Green and Phyt，Blue-Green max increased with each year, but the increase was not significant. The bloom period of PhHyto，Green was from July to September each year, and the peak value ranged from 0.05~0.062 mg∙L-1 (dry weight). The bloom period of Phyt，Blue-Green max was from May to August, and the peak value ranged from 1.25 to 1.45 mg∙L-1 (dry weight). In conclusion, in the predicted three years (2021~2023), the biomass of Phyt，Blue-Green max in the reservoir is the most, followed by PhHyto，Green and Phyt Low-Nut Diatom, and the biomass of Phyt High-Nut Diatom is the least. The biomass of these four species of algae showed obvious seasonal changes, and the bloom period of algae was mainly in August to September when the temperature was high. Among them, the bloom period of Phyt，Blue-Green max was the longest and the vitality was strong.

# 4 conclusion

(1) Through the sensitivity analysis module of the AQUATOX model, key parameters that have the greatest impact on the model results are obtained, such as the optimal temperature，maximum photosynthetic rate, death index coefficient, phosphorus semi-saturation parameters of Phyt，Blue-Green max, the optimal temperature of Phyt High-Nut Diatom, and the optimal temperature of Phyt Low-Nut Diatom. The sensitivity of Phyt，Blue-Green max biomass to Phyt，Blue-Green max related parameters was relatively high, and the sensitivity to the optimum temperature, maximum photosynthetic rate and death index coefficient was 1718%, 367% and 306%, respectively. Based on the results, the key parameters of the model were scientifically calibrated.

(2) The simulation results of the constructed water ecological model are in good agreement with the actual water environment of Sanhekou reservoir, and the average relative error of each index is within 15%, which can reflect the actual situation of Sanhekou reservoir. In 2020, the water quality in the study area was class Ⅱ and Ⅲ, with the concentration of total phosphorus (TP) between 0.015 and 0.029 mg∙L-1, the concentration of total nitrogen (TN) between 0.25 and 0.68 mg∙L-1, and the concentration of ammonia nitrogen (NH3-N) between 0.018 and 0.04 mg∙L-1. The concentration of nitrate nitrogen (NO3) is between 0.18~0.5 mg∙L-1. In dry season and normal season, the concentration of nutrients is low and the water quality is good. Algae have obvious seasonal changes, with the increase of temperature, will usher in a flourishing period; The biomass of Phyt，Blue-Green max was higher than that of other algae from May to August, and the peak biomass was about 1.1 mg∙L-1 (dry weight).

(3) The AQUATOX model was used to predict the evolution of the water ecosystem in Sanhekou Reservoir from 2021 to 2023. The prediction results showed that the seasonal changes of water quality indicators and algae biomass were basically consistent with the simulated situation in 2020. The water quality will be between class Ⅱ and class Ⅲ. The concentration of each nutrient has a trend of increasing year by year, but the amplitude is very small. The concentration of total phosphorus (TP) is lower than 0.036 mg∙L-1, and the concentration of total nitrogen (TN) is lower than 0.73 mg∙L-1, which is still lower than the class Ⅲ water standard of "Surface Water Environmental Quality Standard" (GB3838-2002). Reservoir water quality will continue to maintain a good state; The biomass of Phyt High-Nut Diatom and Phyt Low-Nut Diatom decreased first and then became stable with years, while the biomass of PhHyto，Green and Phyt，Blue-Green max increased with years. The bloom period of algae was mainly in August to September when the temperature was high. The bloom period of Phyt，Blue-Green max was the longest and the biomass was the largest, with the peak value of 1.25~1.45 mg∙L-1 (dry weight).

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