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Research Progress of Underground Water and Water Environment Mathematical Model

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Abstract. Nowadays, as global climate is getting worse, the water used in daily life or industry is not as good as previous time. therefore, it is essential to have the ability to accurately predict the environment of underground water as well as the characteristics of the water itself in order to accurately evaluate the significance of water and underground water. Models such as the generalized channel model, the visual Modflow model, and the generalized boundary and outlet model are used throughout the sections to evaluate underground water and water protection, to apply to some real-world examples, and to forecast future developments. These models are used to apply the findings of the evaluations to real-world situations. The purpose of this paper is to investigate the public's access to and knowledge of the water quality of the Yueyang Yangtze River, as well as to discuss related challenges in the environmental impact prediction of groundwater.

Keywords: Underground water, water environment, mathematical model, Yueyang Yangtze River.

1. Introduction

To better assess the impact of construction projects on underground water quality, the Ministry of Environmental Protection issued a new guide rule at the beginning of the year that expands the scope of evaluation of the underground to include those impacts [1]. However, some outdated norms persist. Meanwhile, to realize the Chinese chairman's vision, we must maintain joint safeguards while avoiding major exploitation. Joint protection of the Yangtze River can be ensured once the top-level design and route planning are completed. Therefore, the water environment management system of central Yueyang city was thoroughly organized and planned as part of the great protection work of Yueyang's Yangtze River. The purpose of this paper is to investigate current efforts to study water quality and its availability.

The study's methodology is based on a number of models, including a generalized channel model, a visual Modflow model, a prediction model for two-dimensional hydrodynamic dispersion, and a generalized boundary and outlet model.

The purpose of this paper is to determine whether or not the groundwater in a given area has been polluted to an unacceptable degree, and to accurately reflect that pollution. There is also the fact that a healthy ecosystem is crucial to a society's long-term success, and as people's standards of living rise,

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the pressure on governments to meet rising demands for clean water means that finding a solution to the problem of black, stinky water is front and center.

2. The choice of the model

2.1. The model used in underground water

The first requirement is that it should function as intended under a variety of conditions. The following are some of the features of this emission rule: Since groundwater is dense at the leak point, the concentration of the pollutant in C1 will be less than C0 as the pollutant continues to discharge. In the end, as depicted in figure 1, point C1 will be very close to point C0.

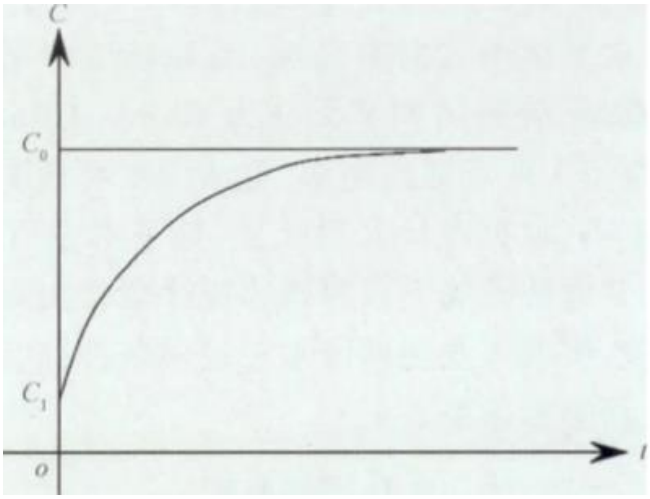


Figure 1. Variation characteristics of pollutant concentration at the leakage point [2].

If we want to accurately predict what will happen in two dimensions of fluid motion, we should use the model developed for predicting steady flows in one dimension (A model of dispersion in two dimensions). To verify the area affected by using the Surfer, it must collect a large amount of data and draw a diagram. In fact, it is indeed pretty strenuous labor. As a result, the Visual Modflow can be employed to resolve the complex model. In this section, the paper explains the used methods.

2.2. The choice of predictive factor

A great deal of the information is irrelevant to the study. Multiple variables are at play, including pHCOD and BOD5. The pH index is a dimensionless measure of pH while the chemical oxygen demand (COD) and biological oxygen demand (BOD5) indices are both all-encompassing measures of the quantity of organic pollutants in water and both are transient [3]. Because of their unique properties, these factors cannot be used to accurately forecast solute transport in groundwater.

2.3. Determination of predicted source strength

As is customary in such endeavors, the source intensity will be established in conjunction with the engineering analysis after the normal and abnormal conditions have been predicted.

For reinforced concrete pool type structures, it is recommended in the interpretation of groundwater guidelines that seepage volume under normal conditions = infiltration area × leakage intensity, and the leakage intensity is set at 2 L /(m^2d) [4]. There are two problems with this approach to measuring the power of the source. One issue is that the pool's anti-seepage measures are really not taken into account when calculating the intensity of the original signal. Two things stand out about this method: first, the amount of leakage determined by it is substantial, as the technical requirements for key impermeable areas and general impermeable areas are different, and as the cement impermeable grade used in the actual construction of the pool is also different. Pollutant discharge must be consistent with

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the requirement that there is no obvious influence on the groundwater flow field before the analytical model can be used to predict the diffusion of pollutants in the aquifer. A typical regulating tank has dimensions of 10m × 10m × 3m, a water depth of 2.5m, and an infiltration area of 200m^2. The leakage volume is 0.4m^2 per day under standard conditions [5]. As the leakage volume increases to 40 m2 / d under abnormal conditions, it is clear that something is not quite right.

However, when using software like Visual Modflow to solve the prediction scenario, the size of the leakage has a clear impact on the flow field; too much leakage causes the water level near the leakage point to be obviously high; furthermore, the calculation results do not conform to common sense, which is not the case when using the analytical method. Leakage of 0.4 m^2/d is a relatively large value [6], and it is expected that a qualified sewage tank that takes anti-seepage measures will have a very small leakage under normal conditions.

Waste water leakage through the bottom of the regulating pool can be estimated under normal conditions using the formula Q = KAI. K is the permeability coefficient of the bottom of the regulating pool, which can be the actual permeability coefficient or the equivalent permeability coefficient according to the anti-seepage technology; Q is the leakage at the bottom of the regulated pool under normal conditions, in cubic meters per day. In light of these unfavorable conditions, the equivalent permeability coefficient is 3.0 × 10-8 cm/s. The hydraulic slope, estimated at 6.56 degrees, is denoted by I, and A is the area of the pool's bottom that needs to be changed (in meters squared). According to the numbers, the leakage at the bottom of the controlled pool is 0.017 m^3 per day when everything is running smoothly [6]. Under abnormal conditions, leakage is ten times greater than normal.

2.4. The result of prediction

The parameters are then substituted into the prediction model after the model, factors, and strength of the prediction source have been determined. The following conditions should be met by the prediction results under normal circumstances: At each stage of the build, all areas outside the field boundary meet the applicable standards with the exception of a small scope that exceeds the standard within the field boundary; The source strength should be recalculated for prediction if the field boundary is outside the standard, and the standard for preventing seepage should be raised if the prediction fails to meet these conditions. Sewage pond anti-seepage measures can be compromised in extreme weather, potentially contaminating groundwater supplies. This is how the forecast outcomes should be presented: To begin, the influence norm of characteristic factors at various times during a project's construction

Measurements for diameter, maximum impact, maximum migration, and maximum range; second, the time-dependent shifts in the predicted values of the characteristic factors for the project boundary and groundwater protection target.

2.5. Summary

1) The impact state of groundwater pollution should be accurately reflected by a two-dimensional hydrodynamic dispersion prediction model used in groundwater environmental impact predictions. 2) When choosing predictors, it is indeed important to think carefully about how relevant feature factors will be to the prediction model. 3) The technical requirements of anti-seepage or specific anti-seepage measures should be fully combined when determining the source strength. Leakage amounts should not be calculated using a leakage strength of 2 L /(m^2d) [7]. 4) Predicting that, under normal conditions, the exit boundary will be at or above the standard, and provide the change rule of characteristic factor concentration at the exit boundary and groundwater protection target over time.

3. The choice of other models

There are other models that can be used to analyze water besides the one used to evaluate aquifers underground. It made use of a mathematical model based on observations of the fluctuating conditions in the Yueyang Beigang River. To that end, it encourages calculation of water's condition in order to examine how that quality varies throughout the year and the spatial compliance rate.

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3.1. Background

The area around the Yueyang Beigang River is put to good use. Yueyang City is on the east side of the Yangtze River where it meets Dongting Lake in northeastern Hunan Province. It shares borders with Jiangxi and Hubei provinces to the north, Changsha City (which includes Liuyang City and Changchang City) in Hunan Province to the south (Shaxian County, Wangcheng district), and Hunan Yiyang City (which includes Yuanjiang City, Nanxian County, and Changde City) to the west (including Anxiang County) [7]. Lake star cloth, river network weave, and an advanced water infrastructure can all be found in Yueyang, a city on the northeastern shore of Dongting Lake. Climate is hot and sticky with plenty of rain because it is in the subtropical humid climate zone.

Annual precipitation averages 1352 mm, while yearly evaporation averages 1446.4 mm [8]. The main river channel of Nanhu's Beandangang River is wide in the city, and the river itself is a branch of the lake's eastern arm. Meixi port, Bashan port, Chai port, Xiong Peng port, and the rest of the affluent tributaries' upstream distribution. Water depth ranges from 1 to 3 meters in the upper reaches of the Nangang River and the upper reaches of the Beigang River and the Beigang River, and from 4 to 5 meters in the lower reaches of the Wuyan Bridge to the screw island section of the three-eye bridge.

3.2. The choice of the researching year

From 1988-2017, Yueyang National Basic Meteorological Station collected annual rainfall data; the year closest to the designed rainfall value was chosen as the typical year, and the typical year from 2003-present, when data reliability was higher, was taken into account [8]. This project uses Yueyang City's 2014 (normal water year) rainfall data to run a long-term simulation of water quantity and quality in order to calculate the annual type of the pipe network.

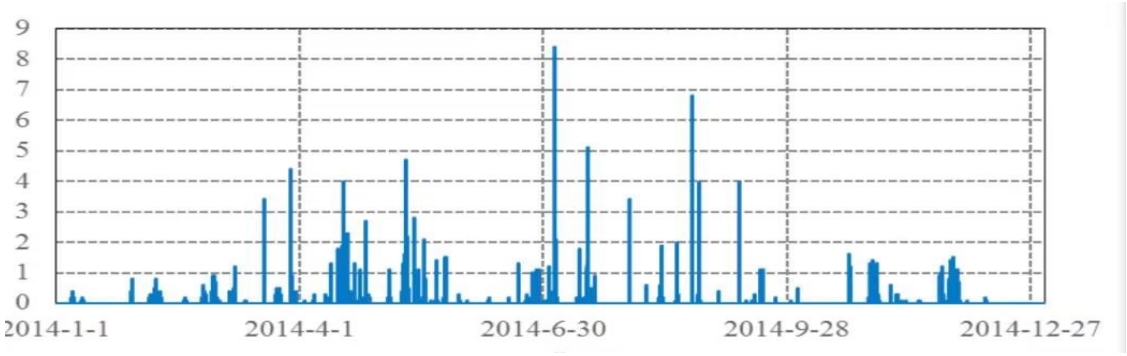


Figure 2. typical annual rainfall process [1].

3.3. Generalized channel

The first is the generic channel. The benefits of the irregular triangular mesh are as follows: The mesh density can be adjusted freely, making it a good fit for both the underwater landscape and the complex boundary shape of the solids themselves. Solid adaptability. In this paper, we built a 1.83km2 triangular grid with no underlying structure. A triangular grid of 5886 triangles and 3,587 nodes was used to divide the landscape into 20-30m cubes with a depth of about 2-4m [7].

3.4. Generalized boundary and outlet

Baihelong Port, Xiong Peng Port, Chajia Port, and Muli Port are all tributaries of the Nangang River in the North and South Ganghe River Basin, while Luqiao Port, Meixi Port, Bashan Port, and the Nangang River are tributaries of the North Ganghe River. The tributaries supply the majority of the water that flows into the main river channel. As it stands right now, about 70,000m^3 of tail water is being discharged into the upstream section of the Beigang River from the Luojiapo Sewage Treatment Plant. The combined volume of the Luojiapo Sewage Treatment Plant's first and second phases is 100,000m^3. South Lake regulates the upstream water level, with a high controlled water level of 27.56m and a low controlled water level of 26.56m [7]. In the lower reaches of the Beigang River, the

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water level of South Lake (27.06m) was chosen as the boundary water level control condition for the Three Eyes Bridge. There are 87 outfalls in the main channel of the Beandangang River; 39 of them serve residents living along the river, 41 drain stormwater, 6 handle sewage from the confluence, and 1 serves as an interception and overflow point for the confluence [8]. In order to generalize accurately from model simulations, it is important to take into account the spatial distribution of tributaries and drainage outlets as well as the pollution level in each. Now, typical drainage outlets are picked to serve as the model's internal point sources, and their generalization is depicted in Figure 4.

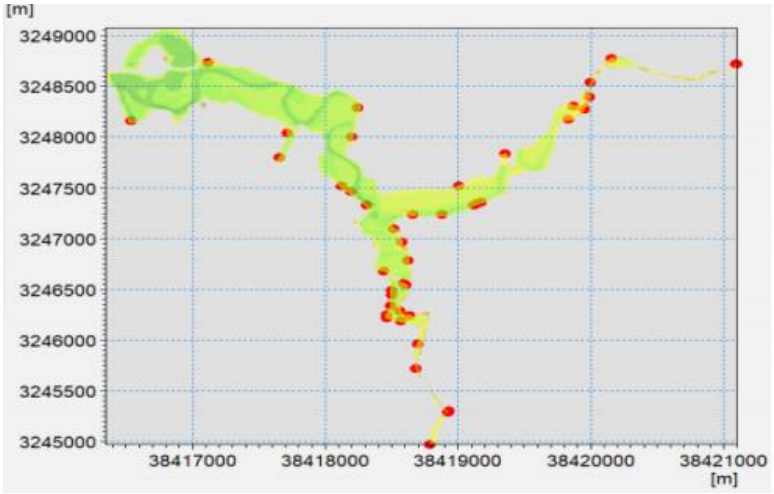


Figure 3. The distribution and generalization of the drainage outlet of the North and South Ganghe River [1].

3.5. Planning effect analysis

Given the gap between water environmental capacity and current pollution in the river, corresponding engineering measures such as pipe network transformation, sponge city construction, agricultural livestock and poultry pollution control, and ecological dredging of endogenous sediment are planned to carry out a comprehensive treatment project in the Beigang River. COD2094.8T/A, NH3-N206.4T/A, TP21.4T/A, and TN294.5T/A were all reduced recently.

Table 1. Total reduction results of pollutants in the watershed.

Drainage basin	The total pollution load(t/a)				Reduction			
	Co	DN3-N	TN	TP	COD	NH3-N	TN	TP
North Channel of the River Estuary	2698.5	214.8	418.8	28.4	1326.9	145.5	206.3	15.1
Nangang River at the mouth of the Yangtze River	1278.1	86.6	142.5	10.7	767.9	60.9	88.2	6.3

The water quality of the Beandangang River significantly improves after the pollution sources into the river are effectively controlled. The water quality of the Beandangang River is good on sunny days, and the overall water quality is class iv. Except for the reach of the tailwater in the sewage plant, COD and TP are essentially class iii. The overall category of a rainy day is similar to that of a sunny day; however, the local pollution area increases, and the overall water quality category is essentially iii-iv (except TN).

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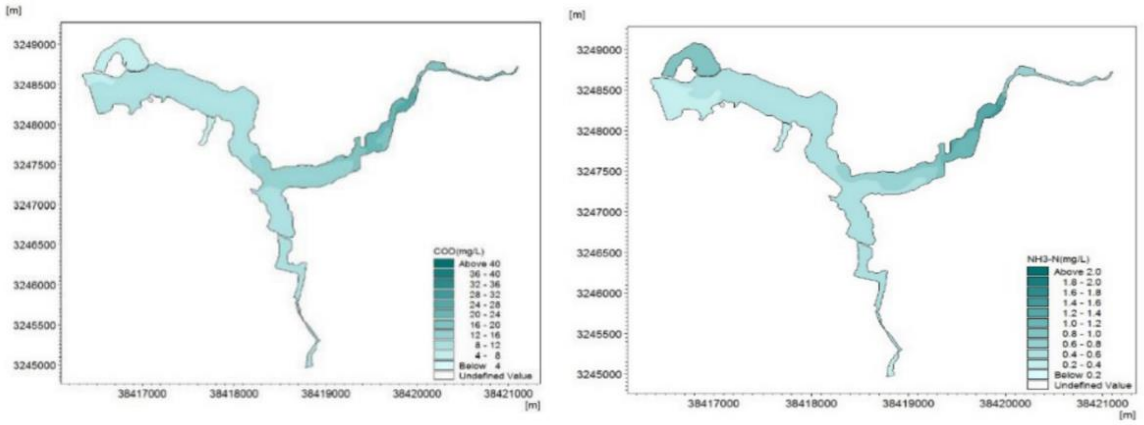


Figure 4. COD distribution (sunny) (left) and NH3-N distribution (sunny) (right) [1].

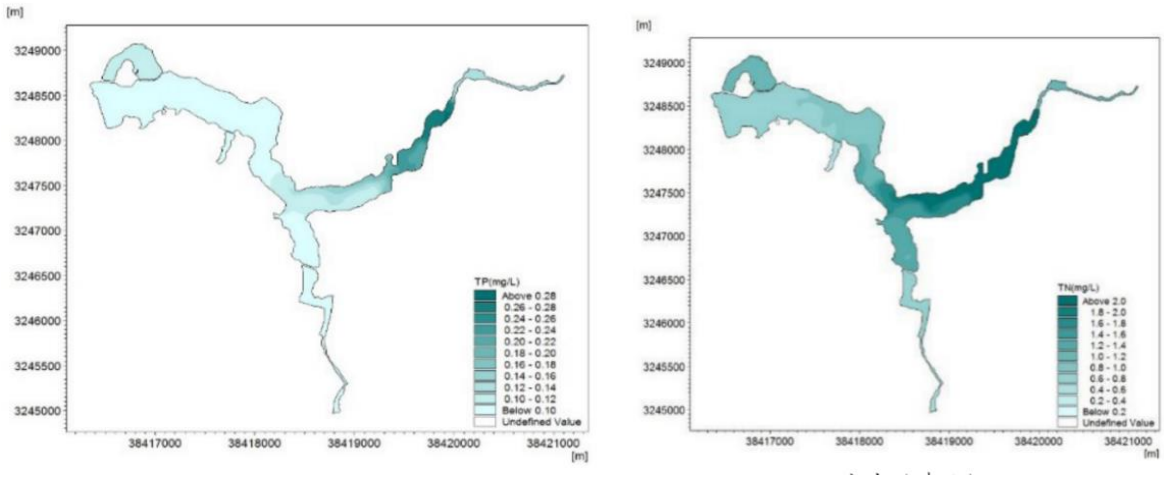


Figure 5. NP distribution (sunny) (left) and Distribution of TN (sunny) (right) [1].

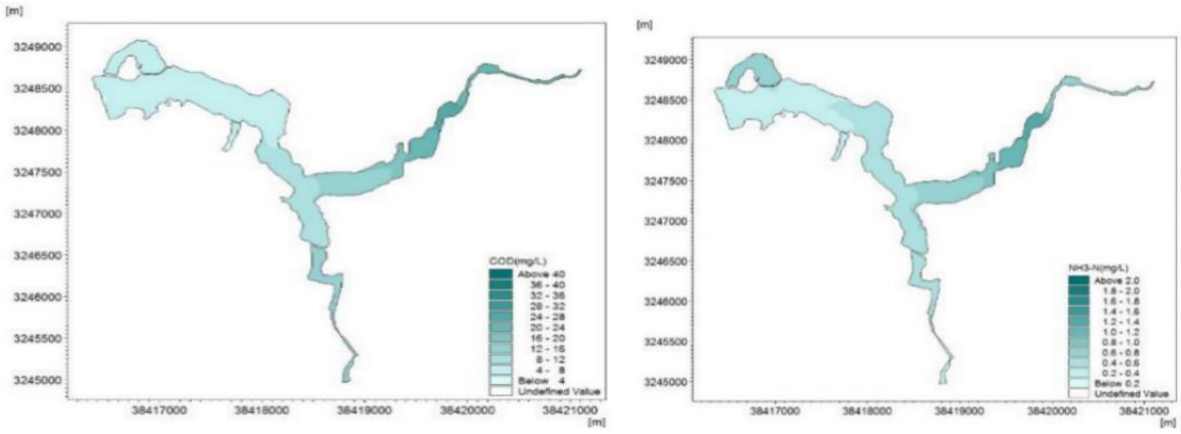


Figure 6. Distribution of COD (rainy) (left) and Distribution of NH3-N (rainy) (right) [1].

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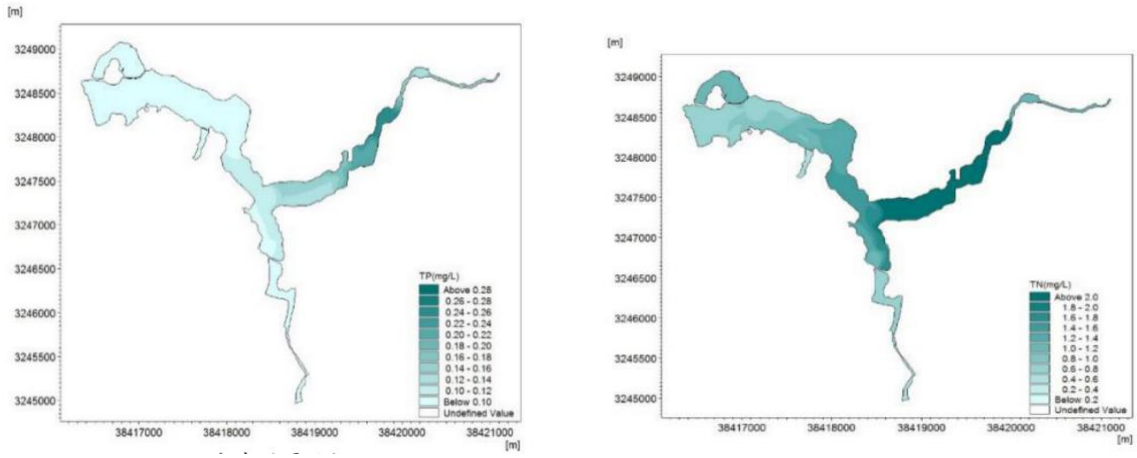
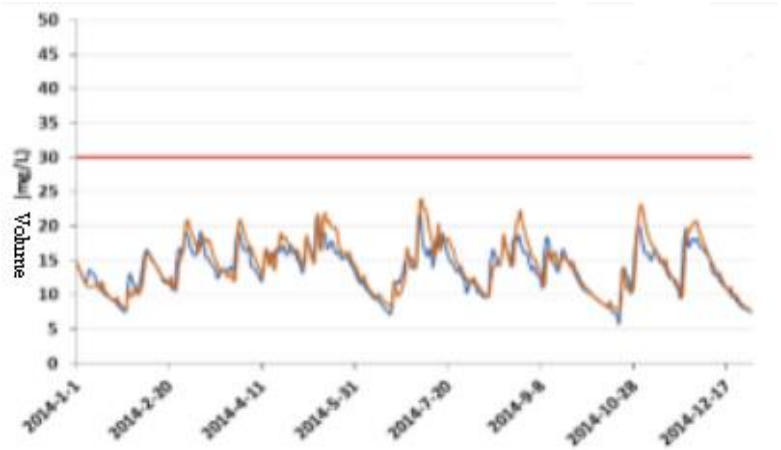
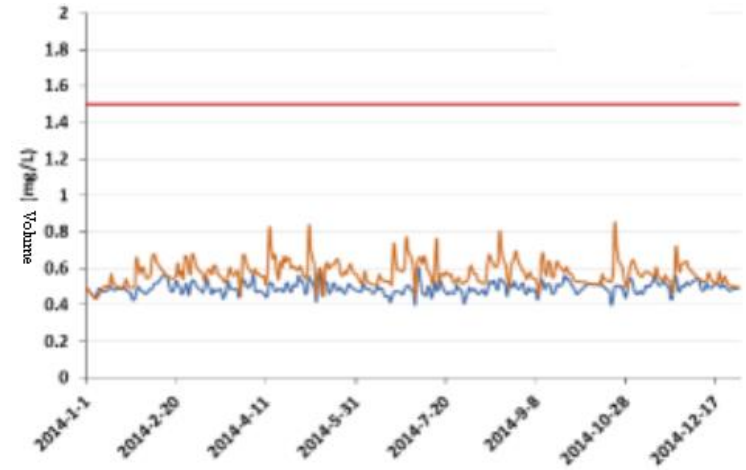


Figure 7. Distribution of TP (rainy) (left) and Distribution of TN (rainy) (right) [1].

The COD, NH3-N, and TP of the Beigang River are all within the standard all year, and the annual compliance rate of the TN Beigang River is slightly lower than that of the Nangang River, and pollutant concentrations rise dramatically at the start of rainfall. Overall, after the plan is implemented, the water quality of the Beandangang River could reach the near-term target of class iv.

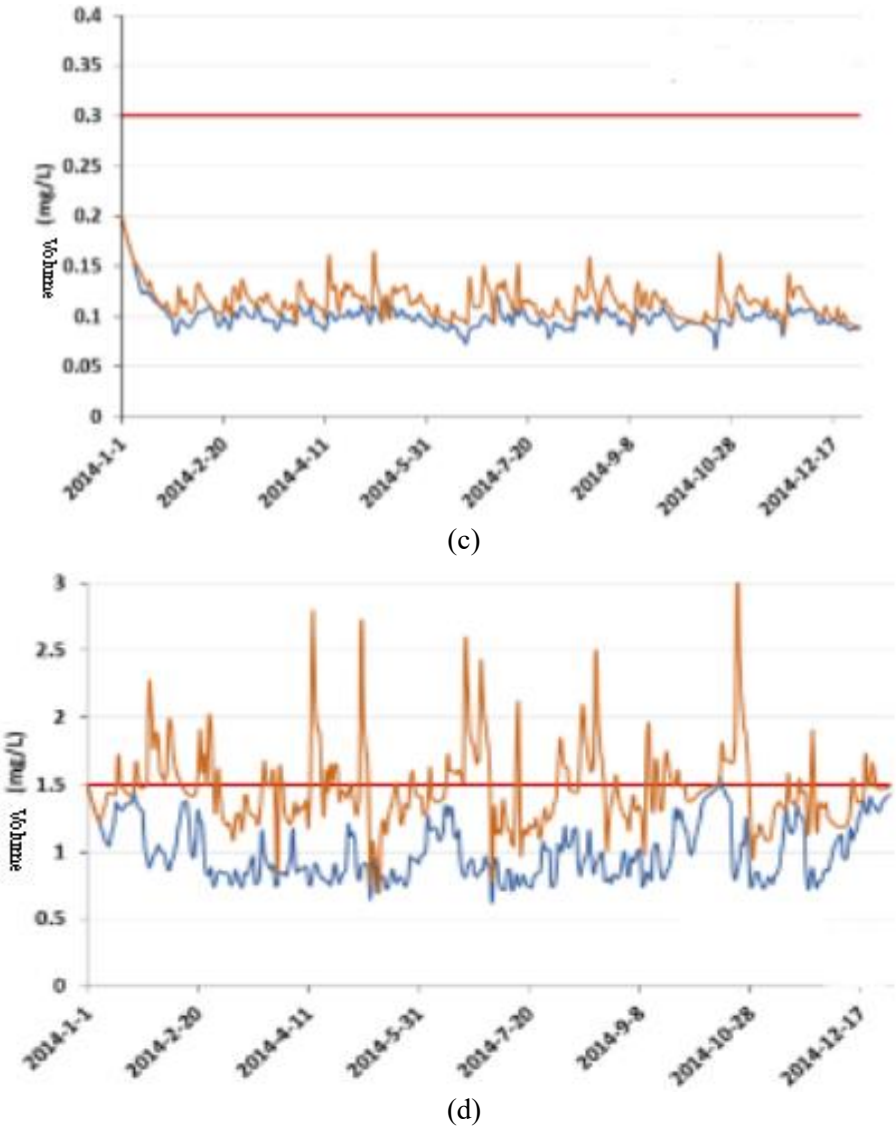


(a)



(b)

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(c)

(d)

Figure 8. the prediction results of water quality change in the year after treatment of the Beandangang River (a-d) [1].

The blue line represents the Nangang River's calculation value. The green line represents the Beigang River's calculation value. The red line represents the IV standard.

4. Conclusion

In conclusion, according to the unsteady water environment mathematical model of the Yueyang Beigang River from relevant research, the annual model of the corresponding pipe network model is calculated after the model has been calibrated and verified based on the current situation of supplementary monitoring data. After the recent project's implementation, the normal water year of 2014 is used as the annual model to calculate the entire year of the Beigang River in the study area.

The above calculation results for water quality simulation show that: the water environment mathematical model established this time can better reflect the water quality change law of the Beigang River, and can be used for water quality prediction under different conditions. The water quality of the Beiangang River meets the requirements of class iv water quality despite recent reductions in COD 2 094.8T/A, NH3-N 206.4T/A, TP 21.4T/A, and TN 294.5T/A. (except TN). COD,

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NH3-N, TP, and TN spatial compliance rates were 99.6, 99.6, 99.6, 74.5, respectively, on sunny days, and 99.6, 99.6, 99.6, 66.4, respectively, on rainy days. According to the spatial distribution of pollutant concentrations on sunny and rainy days, the upper reaches of the Nangang River have better water quality than the upper reaches of the Beigang River. The upper reaches of the Beigang River are impacted by overflow pollution and sewage plant tailwater, while the lower reaches of the Beigang River are gradually improving after the Nangang River enters the Beigang River.

While there may be some issues with environmental protection, one of the most important components is the water environment. These models have the potential to improve environmental conditions. With the improvement of people's living standards, demand for its own ecological environment increases, so how to solve the problem of black smelly water body has become the focus of attention, so in order to provide high quality living and working environment, the national related department should strengthen the study of black smelly water treatment technology and improvement.

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