Water environment mathematical model mathematical algorithm

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Abstract. The mathematical model of water environment refers to the mathematical expression used to describe the water quality factors of water bodies under the influence of various factors that change with time and space and control conditions. It is of great significance to study the parameters of the mathematical model established. The mathematical model of water environment is of great significance to the study of the parameters of the established mathematical model. Water quality can be predicted through the determination of parameters, and water quality can be divided to determine the grade of water quality. The adjustment of parameters can also make the water quality system develop in the direction that people demand.

1. Introduction

Water is the most widely distributed substance on the earth and it is also a very important natural resource. With the rapid development of industrial and agricultural production and the rapid increase in the degree of urbanization, a large amount of waste flows into rivers, seas, and seas, causing water pollution and affecting the use of water resources. In order to eliminate pollution and protect water resources, it is bound to encounter a quantitative assessment of the quality of the water environment. Water pollution is a major “killer” of water shortages. Preventing and controlling water pollution [1] can both promote the improvement of water environment and increase the available water resources. In order to effectively use water resources and improve water quality, research on water environment is increasingly important. With the development of society and economy, population increase and improvement of living standards, the demand for freshwater resources has continuously increased and the quality of water use has become increasingly demanding. Water environmental protection has become an important control factor for the development and utilization of water resources. The main research content of the water environment. The mathematical model of water environment refers to the mathematical expression used to describe the water quality factors of water bodies under the influence of various factors that change with time and space and control conditions. It is of great significance to study the parameters of the established mathematical model. By adjusting the parameters, the system can be developed in the direction required by people [2]. Therefore, how to determine the parameters in the mathematical model of water quality has attracted many people's attention. It is no exaggeration to say that if the parameter calculation problem is not solved and reliable parameters cannot be given, the prediction and control problems will become castles in the air. The prediction and control methods

also cannot solve the actual water quality calculation problem. Therefore, regardless of theoretical methods or actual calculations, the research parameters inversion problem is of great significance [3].

2. Proposed the classification of water quality

As the country has strengthened the control of the opposite sources of pollution, non-point source pollution has decreased, and the input of pollutants in the atmosphere, such as organic compounds, metals, and nitrogen compounds, has become increasingly important for river water quality. Although nutrients and toxic chemicals have been contained within the framework of the model as a result of sedimentation directly into the surface of the water body, the sedimentation load of the atmosphere not only falls directly on the surface of the water body, but also falls within the watershed, and is then transferred to the water body through the watershed. This has become Increasingly important pollution load factors [4]. From the perspective of management development requirements, the addition of this process requires the establishment of an air pollution model that can connect dynamic or static atmospheric deposition to a given watershed for a given atmospheric basin (control area). Therefore, in the establishment of the water environment model, the increase of the air pollution model can be used to evaluate the load from the watershed, as can the direct assessment of air pollution load that has settled into the water body [5].

3. Establishment of mathematical model for water quality classification

This formula is simple and clear, it better reflects the organic pollution and laws of the water body, and it has been widely used so far. Many water quality models were later supplemented and developed on this basis. The water quality model is established according to a certain procedure. Although the establishment process differs depending on the purpose, duration, and factors of the model establishment, the procedures for building the model generally have the following steps: (1) Models (2) Mathematical expressions; (3) Corrections (such as differential or finite element segmentation due to computational needs, etc.); (4) Calibration; (5) Verification; (6) Stereotypes; (7) Applications [6]. In practice, the developed water quality model is generally used. At this point, only the selected water quality model needs to be identified and estimated. The calibration of the model is the use of one or more sets of observed input and output data to adjust, modify, and shape the parameters and structure of the selected model [7]. The model test is to use another set of independent input and output data to test the calibrated model and verify whether the model's predicted results and measured data meet the requirements [8]. The calibration and verification of water quality models can also be collectively referred to as the identification of water quality systems. Its purpose and task are to determine the structure and parameters of the water quality model, which is also called the parameter estimation. The identification of the water quality model is different from that of a general engineering system. The general engineering system can freely select its input function and measure its output with various precision instruments to obtain various data necessary for calibration and verification of the model [9].

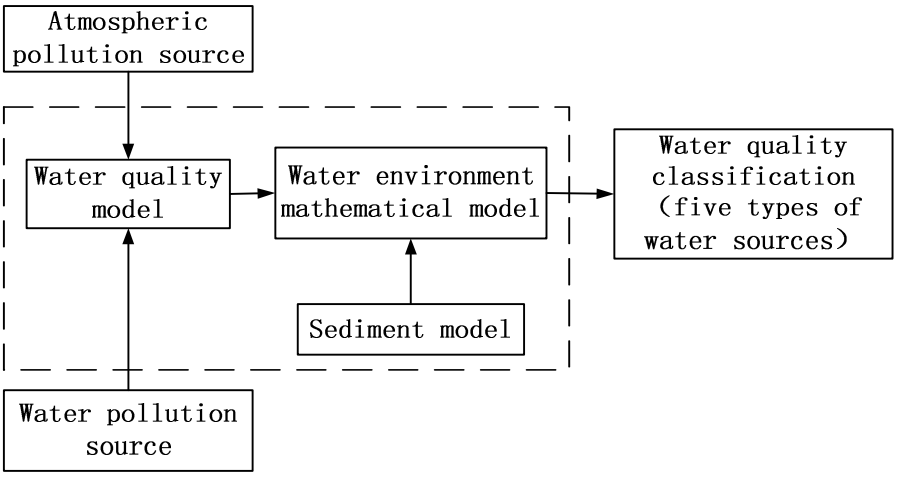

Fig. 1 Flow of mathematics modeling for water environment

3.1. Mathematical model algorithm for water quality classification

According to the hydraulic characteristics of water quality, a one-dimensional push-flow model is adopted, and the flow is designed as a push flow, and there is a dispersion effect. According to the mass conservation principle, the differential equation of the concentration change of a pollutant in the water injection fluid is:

$$\frac{\partial c}{\partial t}+\mu\frac{\partial c}{\partial x}=E\frac{\partial^2 c}{\partial x^2}-kc+R$$

In the formula c-water concentration of a certain pollutant mg/L;
T-time d;
μ - Average flow rate m/d;
X-water body distance m;
E-dispersion coefficient of flowing water m2/d;
K - a pollutant attenuation rate coefficient d-1;
The change rate of a pollutant caused by R-system internal factors is mg/ (L.d).

In steady state, ie at any section x, the water quality does not change with time. In practice, steady state is relatively present when examining the average concentration of water. At this point, $\frac{\partial \mathrm{c}}{\partial t}=0$, Becomes a constant equation:

$$\mu\frac{\partial c}{\partial \mathrm{x}}=E\frac{\partial^2 c}{\partial x^2}-kc+R$$

3.2. Mathematical model algorithm for water quality classification

The solution conditions are: x = 0, c = c0 (water quality of the initial section); when x → ∞, the solution to the water quality is:

$$\mathrm{c}=loe^{\lambda x}+\frac{\rho}{k}(1-e^{\lambda x})$$

Table 1. Classification of Water Quality by Pollution Index Method

c score	0≤c<1.0	1.0≤c<2.0	2.0≤c<3.0	3.0≤c<4.0	4.0≤c<5.0
level	Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ

Water environmental quality standards are the goals and directions of national and local water environment planning and are the basis of environmental management. To date, the state has promulgated a series of water environment quality standards. They are the selection and analysis problems for quality standards for aquatic environment sediments, ecological standards for aquatic organisms, and quality standards for incorporation into surface water bodies. Surface water quality is an important part of water environment systems. Section. At present, the main basis is the national environmental quality standard GB3838-88. Compared with past water quality standards, it is classified according to the functions of water areas, which is more in line with the needs of different targets and environmental protection. In this standard, the grade of water quality is divided into five categories according to the purpose of the use of surface waters and the protection objectives. On March 28, 1994, the Ministry of Water Resources of the People's Republic of China issued the industry standard SL-94 "Quality Standards for Surface Water Resources." Therefore, in the assessment of water quality of rivers, lakes or water quality, they should be measured uniformly according to this standard, so that the results are comparable. Of course, in the five categories, the water quality scale of the same category is not the only one, but varies by interval value.

4. Application of water quality model

4.1. Simulation and Prediction of Pollutant Behavior in Water Environment

The most basic function of the water quality model is to simulate and predict the behavior of pollutants in the water environment. Pollutants are very complex in the process of migration. Using the model method helps to understand the movement of pollutants. Scholars at home and abroad have done a lot of work in this area and the research is relatively mature. At present, the more general idea is to first solve the continuity equation and the momentum equation to obtain the velocity field; then the water quality equation is solved and the pollutant concentration field is obtained. For solving the water quality equations, the traditional method uses finite difference and finite element method. The difference method is not ideal for the curve boundary fitting. The finite element method for solving convection diffusion equations will produce numerical oscillation. The finite volume method combines the advantages of difference method and finite element method. It is the ideal numerical solution method at present.

4.2. Water Quality Management Planning and Evaluation

The basic task of river water quality planning is to determine the amount of pollutants that can be discharged into rivers according to the water quality required by the basic functions of rivers and the self-purification capacity of rivers. For rivers that have already been contaminated, it is how to reduce the amount of pollutants discharged from each pollution source, so that the water quality of the river can be achieved at the minimum cost and within the prescribed time. It is a combination of water quality model and system engineering to seek the optimal solution. In the 1970s of the 20th century, due to the outstanding problem of non-point source pollution, the water quality management model was developed from a single mathematical model of water quality to a composite model system that includes a watershed horological model, non-point source model, and water quality model. In the late 1980s, geographic information systems began to be coupled with the aforementioned mathematical models, forming a relatively complete water quality management system for river basins. Practice has shown that the use of mathematical models for water quality planning can save more than 10% of capital construction investment and operating costs.

In the evaluation of water quality, the water quality model is mostly used in environmental assessment of warm water drainage to the eutrophication of the water environment. Temperature drainage is mostly fire, cooling water in nuclear power plants. After the warm water enters the water body, the water temperature in the local area near the water outlet increases, which accelerates the decomposition rate of nitrogen and phosphorus in the organic matter and promotes the algal growth and eutrophication. Therefore, the warm water drainage is a special form of pollution. According to the current research situation, the assessment of eutrophication of water bodies by warm water drainage can be divided into two phases. Firstly, the flow field and temperature field are solved according to the momentum equation, continuous equation and temperature equation, and secondly, the material transport equation and each biochemical reaction function are obtained. Calculate the concentration distribution of chlorophyll a, total phosphorus, and total nitrogen. The two-dimensional conserved shallow water circulation equation and energy equation are used to solve the flow field and temperature field of Douche River water quality. Based on this, the ecological dynamic model is used to solve the distribution of chlorophyll a, and the effect of warm water drainage on the eutrophication of Douche water is simulated. .

4.3. Calculation of Water Environment Capacity

Water environment capacity is the maximum load or capacity of pollutants that a certain water body can hold under the specified water environment objectives. The research object is the self-purification capability of the water body. In practice, environmental capacity is the basic basis for the management of environmental objectives, the main environmental constraints of environmental planning, and the key parameters for the total amount of pollutants to be controlled; the total amount of pollutants in rivers is also based on the water environment capacity of rivers. The combination of dynamic water quality models and linear programming for the calculation of water environment capacity has features such as high degree of automation and high precision. The main idea is to establish pollutant discharges and control sections for all river sections based on hydrodynamic models and dynamic water quality models. The dynamic response relationship between the water quality standard concentration and the maximum total pollution load of the river is the objective function. The constraint set is: each river segment meets the specified water quality goals; each river section has the capacity constraint that each river section must have a minimum Capacity constraints to meet the total surface pollution source requirements for entering the river. Use the optimization method to solve the maximum pollution load that the river water quality meets a given water quality goal at each moment.

4.4. Water Quality Warning and Forecast

Water quality early warning refers to the analysis and evaluation of water quality conditions for a certain period of time within a certain range, monitoring and analysis of changes in the impact of water environment, and assessment of their capacity, through the analysis of the ecological environment and human behavior. Its occurrence and its future development forecast. Determine the status of water quality, trends and speed of water quality changes, time to reach a certain change limit, etc., predict the temporal and spatial extent and degree of damage of abnormal conditions, and timely provide various alert information for changes or deterioration and corresponding comprehensive Sexual countermeasures, that is, to propose solutions to the problems that have emerged, and to provide preventive measures and corresponding levels of warning information for problems that do not appear or are about to emerge. The technical methods for water quality early warning mainly use theories of computer technology, environmental science, and systems science, mainly GIS technology, especially the use of GIS spatial data management functions and model analysis capabilities to integrate water quality, mathematical model of water quality, and water pollution. And geographical information, etc., together with advanced technology, comprehensive analysis, calculation, and evaluation are performed to solve the problem of the lack of space in the traditional database structure, the inability to realize space management and spatial analysis, and the water quality information from a single Forms and data come out and are presented to decision makers, managers, and researchers in

vivid graphics and images. At the same time, the use of GIS technology established by the early warning information graphics library, to achieve the interactive performance of data and graphics, increase the visibility of the system, improve the ability of analysis and decision-making.

5. Development trend of water quality model

5.1. Development of a New Water Environment Model

The application of new technologies to deepen the study of uncertain water quality models for the mechanism of pollutant diffusion and transport In the field of lake eutrophication research, people have a relatively shallow understanding of the eutrophication mechanism, especially the lack of mechanisms for the growth of algae and phosphorus. The deeper understanding of processes such as sedimentation mechanisms has led to eutrophication mathematical simulations that are far from satisfactory. In addition, due to phosphorus input concentration, light and other factors are actually random changes in the process, not a definite process, so the use of a deterministic differential equation simulation will produce larger errors, and the application of stochastic differential equations to describe, then overcome the determination The disadvantages of sexual differential equations have achieved satisfactory results.

The current uncertain water quality models, although they are of different types, are essentially the same. The stochastic theory is expressed in terms of probability, while fuzzy mathematics is attributed to ambiguity and gray theory to grayness. Among them, the stochastic method theory is the most widely used and the method is relatively complete, including discrete stochastic process classes based on Markov chains and stationary time series. Real-time estimation and prediction of stochastic noise terms and deterministic and stochastic differential equations are included in a deterministic model. class. Since the discrete stochastic process class only considers certain aspects of uncertainty, its shortcomings are also obvious. At present, research has been greatly reduced. The real-time estimation and prediction class is mainly used for real-time estimation and correction of parameters and real-time estimation and prediction of state variables. The differential equation with random coefficients has a simple structure and a large amount of information, which is convenient for decision-making organizations. It has been widely used in foreign countries, but its parameter identification method still needs improvement.

5.2. GIS water environment ecological comprehensive model

GIS technology can digitally process complex and varied natural and social changes and changes in the form of graphics and images. The basic data, hydrology and pollution source data of the river channel are input in its space and property database. Using its spatial database acquisition, management, operation and analysis capabilities, water quality monitoring and evaluation can produce a new look. By calculating the water quality model, we can obtain the locations of the sections that reflect the characteristics of water flow and water quality changes, and show the spatial characteristics, statistical characteristics, and future trends of water quality changes in water areas with realistic images. The mufti-medium environment refers to the total environmental system composed of the atmosphere, water body, soil, and organisms, among which the water body is the core. The pollutants in the environment are distributed in multiple environmental media, and the multimedia environment model can associate the pollutant change process in different environmental units with the process that causes pollutants to cross the media boundary, forming a description in the Expressions of contaminant conversion and material migration between media in a multi-media environment.

5.3. Computer Simulation Water Quality Algorithm

With the development of computer and space technology, computer technology has been able to obtain a large number of visible, infrared, microwave radiation and radar data of different resolutions and multi-spectrum segments at the same time. It has been able to quickly provide a variety of earth observations. Sexual dynamic data, and analysis and processing of these data. Since the 1980s,

scholars at home and abroad have applied this technology to do a lot of work for the protection of water resources and water quality, such as the use of color infrared projection, thermal infrared, and mufti-spectral techniques to study river and lake water pollution; using multi-band remote sensing images to study certain waters Exploring the distribution of suspended matter and sediment; Using microwave remote sensing to study the salinity and temperature in the estuary near-marine waters; Using satellite remote sensing technology to estimate the water chlorophyll concentration; Using the mufti-spectral scanner to study the primary growth rate and red tide in the offshore and estuary.

6. Conclusion

In summary, the mathematical model of water environment refers to the mathematical expression used to describe the water quality factors of the water body under the influence of various factors that change with time and space and control conditions. It is of great significance to study the parameters of the established mathematical model. By adjusting the parameters, the system can be developed in the direction that people demand. Mathematics is the language of science and the foundation of natural sciences and engineering technology. In the research and practice of science and technology, this article aims at the corresponding introduction and comprehensive overview of the mathematical model of water quality and water environment, and studies and establishes mathematical models of water temperature, water quantity and water quality in water quality and water environment. Through mathematical models and empirical formulas commonly used at home, various methods are evaluated. Combined with the characteristics of water quality, comprehensive analysis and research are conducted on the applicability and rationality of the methods to determine the water temperature and quantity suitable for water quality. The calculation method of water quality gives a mathematical model of relatively accurate water quality, which provides an important basis for the environmental impact assessment of other aspects of water quality.

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