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Simulation of Water Pollution Control Engineering Based on Support Vector Machine Model

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Abstract: With the continuous progress of industrialization, the social economy has shown a rapid growth trend, and the living sewage discharge has also increased, which has led to a decline in the quality of the surface water environment and harmed human health. Water quality has become a major factor restricting the sustainable development of economy and society. In view of the frequent occurrence of water pollution accidents and the deterioration of water environment, people pay more and more attention to the prevention and protection of water resources. However, the traditional manual control method cannot effectively solve the problem of water pollution, so it is necessary to innovate the existing technology. Automatic control technology and information technology can be combined to realize online monitoring of pollutants, so as to achieve real-time monitoring and timely warning. Support Vector Machine (SVM) is an adaptive processing method based on machine learning algorithm. By training the neural network, more accurate results can be obtained. To some extent, it overcomes the shortcomings brought by manual operation and has a broad application prospect in the field of environmental monitoring. This paper combined SVM and artificial neural network to develop a set of water quality automatic monitoring system, and used SVM model to predict sewage concentration, which also combined Back Propagation (BP) network to optimize parameters to improve detection accuracy. Finally, by strengthening the application of technology, a scientific and effective evaluation system was established to achieve the goal of water pollution prevention and control. Compared with traditional prevention and control methods, intelligent water environment treatment based on SVM model could quickly and accurately identify the water quality status, and the work efficiency was also improved by 19.35%. It could quickly and accurately determine whether there were toxic and harmful pollutants in the sewage, thus ensuring the health of the people and reducing the occurrence of environmental pollution events, which provided strong support for environmental protection.

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1. Introduction

Due to the special environmental and geological characteristics of the water environment, a large amount of groundwater resources would be generated during its formation. However, due to the complex hydrogeological conditions and artificial mining, some problems in practical application have been caused. The most important ones are serious water pollution and substandard water quality. These problems would directly affect the daily life and production activities of the people, so the importance of water environmental pollution must be strengthened.

The prediction of water pollution has always been a difficult point, and many scholars have made in-depth research in this field. Lee Chang-Gu alleviated the performance inhibition in water pollution by removing the symbiotic organics with oxidizing ability, and significantly reduced the reaction power required for removing this endocrine disruptor in the presence of oxidants to remove or inhibit the organics, so as to improve the efficiency of photocatalytic water treatment and reduce its energy demand [1]. Li Zhou discussed the impact of river head system on reducing agricultural water pollution, and put forward countermeasures from two aspects of governance measures and management methods. He also established water environment quality evaluation system and early warning model, and realized the coordinated development of water conservation and environmental protection [2]. Chen Sophia Shuang investigated the impact of urbanization on river water quality through the gradient evaluation method from top to bottom, and studied the difference of pollution degree between different cities through water quality index and statistical method, thus providing basis for formulating scientific planning [3].

In order to understand the relationship between different groundwater quality parameters, Wu Jianhua traced the source and influence factors of groundwater pollution through statistical and multivariate statistical techniques, which was helpful to understand the change of groundwater quality in urban areas [4]. Singh Nirala studied the role of electrocatalysis in the remediation of water pollutants, and found that adding a certain proportion of electrocatalyst to water could effectively improve the efficiency of biological nitrogen removal, which also reduced the pollution of sludge to the environment [5]. Haghiabi Amir Hamzeh investigated the performance of artificial intelligence technology in water quality prediction, and evaluated the accuracy of the applied model according to the error index, which provided an effective decision-making tool for solving practical problems [6]. The treatment of water pollution was a complex and arduous project, which required not only the comprehensive application of various technologies and means in many professional fields, but also a large number of human and material resources.

SVM has a wide range of applications in water quality prediction, and many scholars have explored based on it. Ni Qihang used the SVM based on principal component analysis to comprehensively evaluate the groundwater quality. Compared with the traditional water quality evaluation method, the improved SVM algorithm made up for the shortcomings of the traditional method, and had good stability, higher accuracy and calculation efficiency [7]. Sakaa Bachir used the sequence minimum optimization SVM and random forest algorithm as the benchmark model for predicting the water quality value of river basins, and found that the random forest generated more accurate water quality index prediction, thus revealing the improvement of the early water quality index prediction tool [8]. Sheng Jichuan described the existing treatment forms in the South-to-North Water Transfer Project. He pointed out its problems and potential solutions, and looked forward to the possible water pollution treatment measures in the future [9].

Bekkari Naceureddine used artificial neural network to predict and control the Chemical Oxygen Demand (COD) of the effluent from the sewage treatment plant, and adjusted the output of the model in real time according to the water quality data and operation conditions, thus realizing the water quality regulation in the sewage treatment process [10]. Liu Yi studied the qualitative and quantitative analysis of the relationship between water pollution and economic growth, thus aiming to reveal the changes in the demand for water resources caused by economic development, which provided scientific basis for decision-making departments to formulate water security policies [11]. Liu Ze-jun performed online prediction of COD of effluent from anaerobic wastewater treatment system based on principal component analysis and SVM algorithm to better realize parameterization of hydrodynamic model under complex water quality conditions, which could help guide actual engineering design and optimal control [12]. SVM method had strong learning ability, adaptive characteristics and good generalization. It could solve the problem that conventional machine learning could not deal with large sample feature sets in the field of water pollution prevention.

In order to solve the current nonstandard phenomenon of water environment treatment and ensure the health of the people, it is necessary to carry out comprehensive treatment from various aspects. As a new and efficient pattern recognition method, SVM can better integrate the data set information into the feature space to obtain more accurate prediction results, and can be used to predict the groundwater quality status to achieve the purpose of governance. Compared with the traditional BP neural network, SVM has stronger learning ability and generalization ability, and can make more accurate judgments for the environmental state to avoid human waste.

2. Water Quality Detection and Pollution

Water quality detection is an important part of water pollution control and an indispensable link in water resources protection, which is of great significance for ensuring people’s life and production as well as social and economic development [13]. At present, water quality monitoring technology has been implemented as a key basic project and has achieved good results. Through scientific and effective water environment monitoring, people’s physical and mental health and personal safety can be ensured. However, in reality, due to people’s lack of comprehensive understanding of water quality monitoring technology and inadequate management, many water pollution phenomena have occurred, thus seriously affecting the health and life safety of the people. Therefore, it is necessary to strengthen the research on water quality monitoring technology to achieve the water quality monitoring objectives.

2.1. Water Quality Monitoring Method

2.1.1. BP Neural Network Model Framework

In recent years, with the development of computer technology and the emergence of various new technologies and processes, people can quickly and accurately get the information they need, and then solve the problem. BP neural network model is an advanced prediction method, which can better reflect the relationship and change rules between things, and has high accuracy and rapidity. At present, it has become one of the mathematical models widely used in many fields. In water pollution assessment, it can effectively solve the real-time online detection and evaluation of water environment quality in complex environments, and can also improve the water quality monitoring and early warning level [14]. The basic framework and specific application of the model are shown in Figure 1.

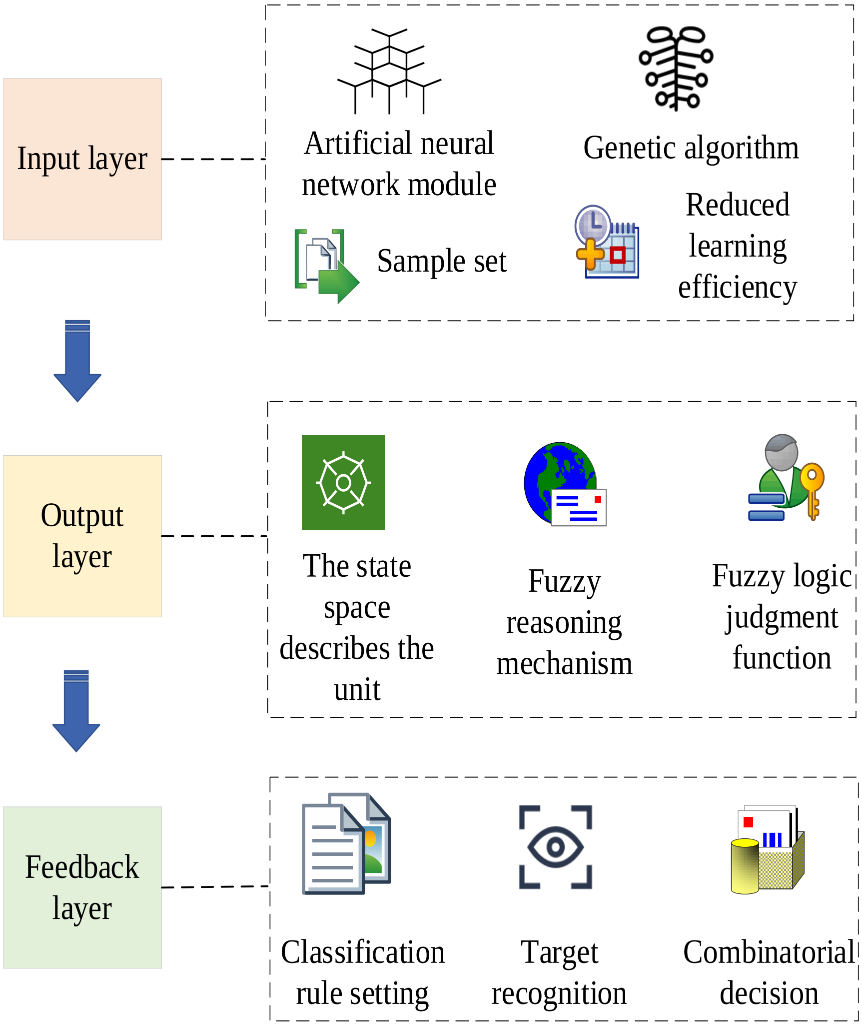


Figure 1. Basic framework of BP neural network model

The basic framework of the model is mainly composed of three layers. The first layer is the input layer, which includes the artificial neural network module and the genetic algorithm. The neural network module is used to build the sample set; the combination of genetic operator and simulated annealing algorithm can reduce the problem of learning efficiency reduction due to insufficient sample number in the training process. The second layer is the output layer, which includes three parts: The state space description unit, the fuzzy reasoning mechanism and the fuzzy logic judgment function, which are respectively used to deal with the relationship between data points and give corresponding conclusions, so as to realize the fast search of the optimal solution of parameters in nonlinear programming. The third layer is the feedback layer, which includes classification rule setting, target recognition, combination decision, etc., so as to ensure the stability of the global optimization performance of genetic algorithm and improve the running speed of the entire optimization program.

When the BP neural network model is used to predict the water pollution situation, it is necessary to first establish the water quality evaluation index system, and then determine the index weight through the fuzzy comprehensive evaluation method, so as to finally calculate the final predicted value by weighting each index, so that the assessment task of environmental quality can be completed automatically by computer. This method is a relatively mature method at present, but it is easy to be affected by human factors and other factors, thus resulting in slow convergence speed, easy to fall into local minimum or over-fitting, and low accuracy. Therefore, new technology is needed to solve this problem.

2.1.2. Basic Structure of SVM Model

The main disadvantage of the traditional artificial neural network method is that it can not effectively predict the degree of pollution, and it is easy to be disturbed by noise, resulting in slow convergence speed, which affects its ability to study and identify the distribution characteristics of pollutants in complex environments. SVM model has good robustness, high accuracy of nonlinear mapping, easy programming and other characteristics, which can better overcome these shortcomings, and may become an effective way to solve such problems [15]. The basic structure of the model is shown in Figure 2.

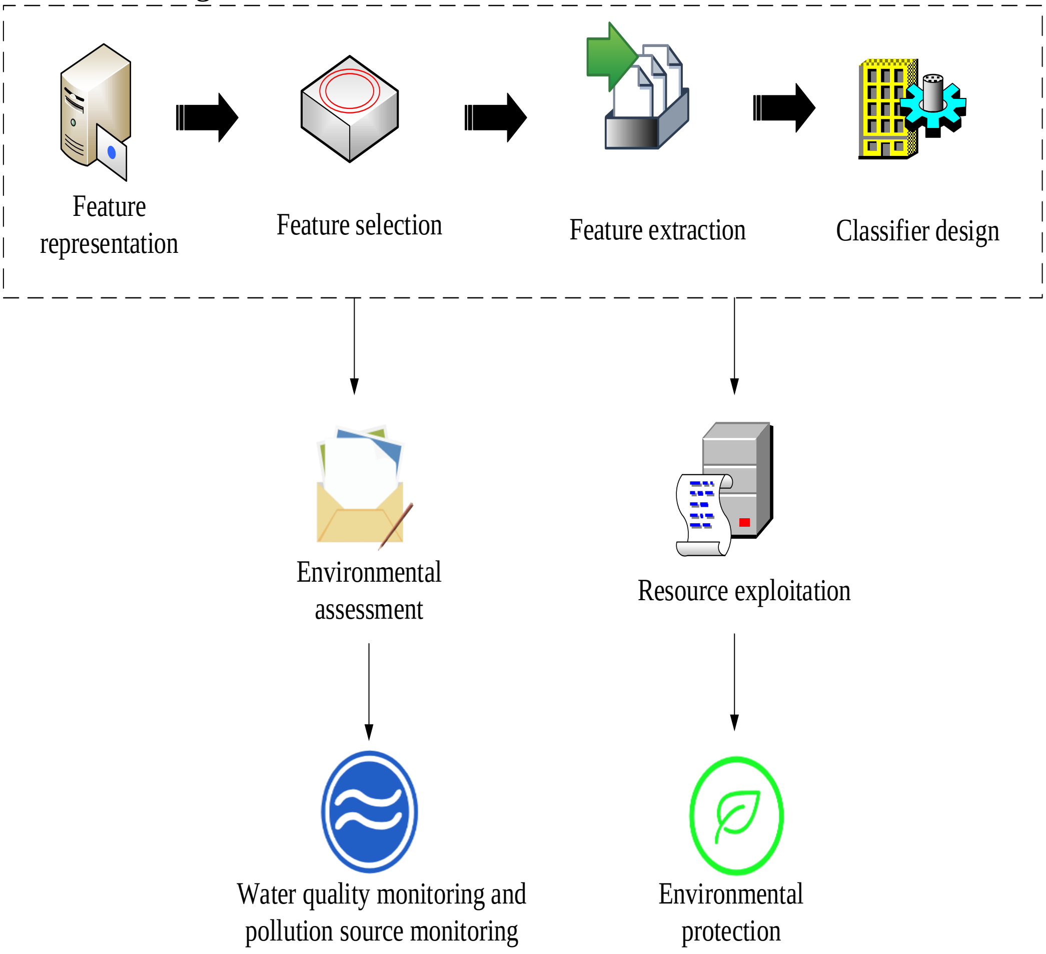


Figure 2. Basic structure of SVM model

The SVM model mainly includes four levels: feature representation, feature selection, feature extraction and classifier design. Each stage needs one or more algorithms to complete. Finally, SVM is trained using sample data based on classification rules and membership. First of all, according to different types of factors, the corresponding cluster tree is established, and the relationship and correspondence between each category are obtained through these divisions. The cluster analysis tree is further refined to divide all possible classes with similar structure into several groups, and a certain number of representative variables are used to form a fuzzy set, so as to determine that there is some similarity between the subsets. Finally, the result is used as a pattern recognition criterion to make decisions, so that it can automatically select the best scheme. At present, this method has been successfully applied to hydrological forecasting, which is mainly used for water quality monitoring and pollution source supervision in environmental assessment and widely used for environmental protection in resource development [16].

2.2. Prevention Simulation Based on SVM Model

As a feature-based pattern recognition method, SVM model trains and classifies input data and outputs prediction results. In practical applications, it is often necessary to build classifiers through a large number of samples to achieve learning objectives, so as to improve the performance of machine recognition. As an efficient and stable decision support system, SVM can be widely used to guide the work of water environment protection. Based on this, a simple and practical automatic collection system for water quality monitoring data is designed, as shown in Figure 3.

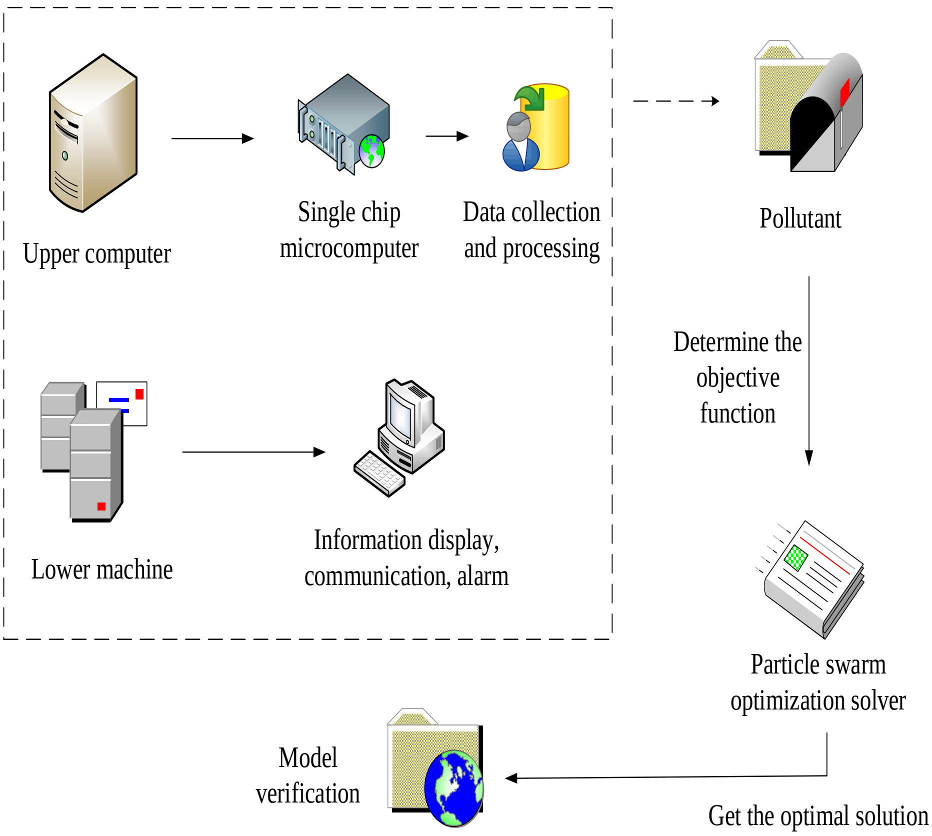


Figure 3. Prevention and control simulation based on SVM model

The system is composed of upper computer and lower computer. The upper computer is a hardware platform based on single-chip microcomputer, which is mainly used for data collection and data processing; the lower computer is an embedded operating system, which is mainly responsible for information display, communication module and alarm prompt function. Firstly, it is necessary to determine the objective function according to the degree of harm caused by different pollutants to the water environment; secondly, the obtained objective function is substituted into the particle swarm optimization solver to obtain the optimal solution. Finally, the validity and accuracy of the model are verified by using Matlab software.

Compared with the traditional algorithm, the advantages of this model are as follows: First, by classifying and analyzing the current situation of river basin pollution, SVM can well identify the key factors affecting the water environment quality from the actual situation and propose targeted measures. Secondly, wavelet neural network algorithm is used to improve the accuracy of water quality prediction, which overcomes the problems of slow convergence in traditional BP network. Thirdly, the water quality evaluation system based on SVM is established by combining the artificial neural network method to make it closer to the real value, so as to effectively improve the reliability of the water quality evaluation results.

3. Establishment and Improvement of SVM Model

The SVM model is optimized based on PSO. The particle position is used to replace the value of the solution, and its velocity vector is determined according to the particle size and direction. The expressions of velocity and position are as follows:

$$v_x(t+1) = av_x(t) + b_1c_1(q_x - i_x(t)) + b_2c_2(q_x - i_x(t)) \tag{1}$$

$$i_x(t+1) = i_x(t) + v_x(t+1) \tag{2}$$

Among them, $v_x(t+1)$ and $v_x(t)$ represent the velocity of particles at t+1 and t; $i_x(t+1)$ and $i_x(t)$ are the positions of t+1 and t; a represents the index weight; b_1 and b_2 are learning factors, which are natural numbers between 0 and 2; c_1 and c_2 are random coefficients, which are natural numbers between 0 and 1.

The SVM model may have judgment error in prediction. It is assumed that the relative error is XE, it can be expressed as follows in the form of formula:

$$XE = \frac{Q' - Q_s}{Q_s} \tag{3}$$

There are a total of N samples. W represents the logarithm of the consistent elements in the model and the measured results, and its expression is as follows:

$$W = 1 - \frac{\sum_{T=1}^{N}(Q' - Q_s)^2}{\sum_{T=1}^{N}(Q_s - \overline{Q_s})^2} \tag{4}$$

The consistency coefficient is as follows:

$$H = \frac{W - M}{\frac{1}{2}N(N-1)} \tag{5}$$

Among them, Q' is the simulation result; Q_s is the measured result; $\overline{Q_s}$ is the mean value of the measured results; M represents the logarithm of elements that are not consistent between the model and the measured results.

4. Evaluation of Simulation Results of Water Pollution Prevention and Control

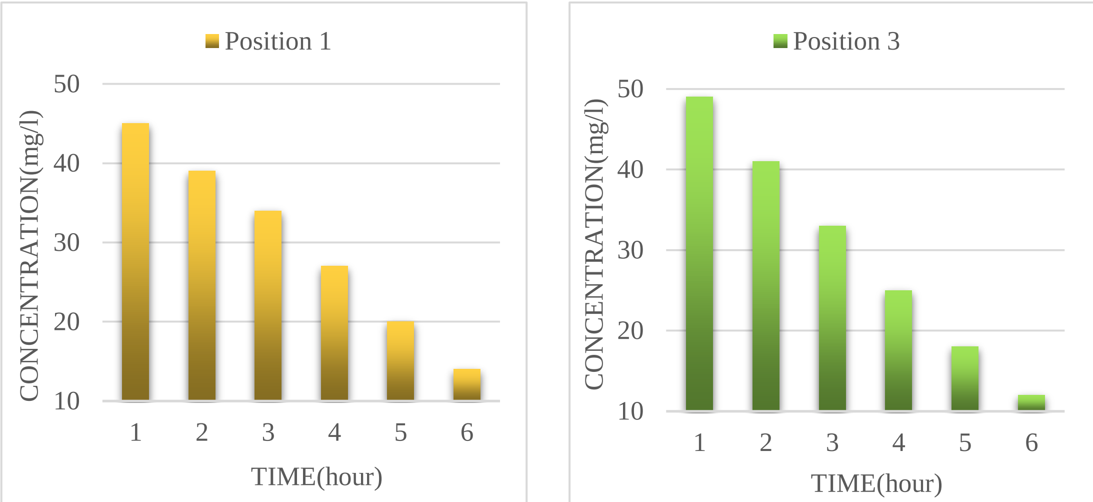
By taking a piece of water in a city as the research object, the water pollution in five different locations was treated. Two of them were selected as the experimental group to conduct governance based on neural network model, and the other three were selected as the experimental group to conduct comprehensive governance based on SVM model. The intelligent monitoring system was used to detect the concentration change of COD before and after the treatment of two groups for a period of time, and the results were shown in Table 1.

Table 1. Changes of COD concentrations before and after treatment at 5 locations

	Before	After
Position 1	45	31
Position 2	55	34
Position 3	49	26
Position 4	51	27
Position 5	40	19

As shown in Table 1, the COD of these five locations before treatment was above 40mg/l. The maximum even reached 55mg/l, and the water pollution was relatively serious. After the treatment by neural network method, the COD at positions 1 and 2 decreased from 45mg/l and 55mg/l to 31mg/l and 34mg/l respectively, with obvious improvement effect. After the treatment of SVM model, the concentration at positions 3, 4 and 5 also changed greatly. Especially at position 4, the concentration decreased by 24 mg/l. It showed that SVM could well predict the water quality and carry out advanced treatment of water body, which was conducive to improving the level of water pollution prevention.

The COD concentration difference between position 1 and position 3 before treatment was small. In order to facilitate calculation, by taking these two locations as the research object, it was required that their COD concentration should reach 15mg/l. At the same time, prevention and control measures would be implemented for these two locations. The concentration change after 6 hours was counted and the working efficiency of the two methods was compared. The results were shown in Figure 4.



a. Change of COD concentration at position 1 *b. Change of COD concentration at position 3*

Figure 4. COD concentration changes at two locations after treatment for 6 hours

As shown in Figure 4, Figure a showed the change of COD concentration at position 1, and Figure b showed the change of COD concentration at position 3. It could be clearly seen that the COD concentration at both locations reached the standard when the test was carried out at the 6th hour. The concentration of position 1 in the first hour was about 45mg/l, and the concentration in the sixth hour was about 14mg/l. The concentration at position 3 was about 49mg/l in the first hour and about 12mg/l in the sixth hour. It showed that the control effect of position 3 was more obvious than that of position 1 at the same time. After calculation, the COD concentration at position 1 decreased by about 31 mg/l, and that at position 3 decreased by about 37 mg/l. The working efficiency of position 3 was about 19.35% higher than that of position 1. Therefore, by using SVM technology to remove water pollutants, it had a good application prospect and could improve the operation efficiency of the water treatment system.

5. Conclusion

Water pollution has become one of the main factors affecting people's quality of life. It is urgent to strengthen the research and promotion of water pollution prevention and control technology. The SVM-based water quality prediction system realizes the information sharing between water resources and water environment management departments through real-time monitoring of the concentration of pollutants in the water body, which is convenient to accurately judge the degree of pollution and effectively control the discharge of pollutants. In this paper, SVM was used as a learning algorithm to realize water environment early warning. Experiments showed that this method could complete water quality prediction quickly, efficiently, accurately and reliably, which had high practicability and effectiveness in urban sewage treatment and pollution source monitoring.

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Data Availability

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

Conflict of Interest

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

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