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Water Pollution Early Warning Method Based on Cloud Platform

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Abstract: In order to meet the actual needs of environmental emergency management informatization, and to deal with the real-time nature of accidents and the in-depth treatment of pollution accidents in water pollution emergencies, this paper used cloud computing technology and mobile communication platform as the communication transmission network to build a cloud-based architecture, and proposed a cloud-based method for water pollution emergencies. Many researchers have provided new ideas for the research of water pollution early warning methods based on cloud platform, which is the research direction and basis of this paper. This paper analyzed the research of water pollution early warning methods, and carried out academic research and summary on the monitoring technologies commonly used in water pollution early warning methods. Then, an algorithm model was established and relevant algorithms were proposed to provide theoretical basis for the research of water pollution early warning methods based on cloud platform. At the end of the article, the simulation experiment was carried out, and the experiment was summarized and discussed. The accuracy of the early warning system for two cities in a certain region was analyzed, and the water quality before and after the use of City Y was discussed. Finally, the difference between the reference values of dissolved oxygen, turbidity and dissolved solids before and after the use of the city was 3, while the difference between the reference values of total bacterial count before and after the use of the city was 5. According to the description of the above data, the water pollution early warning system established by City Y based on the cloud platform is conducive to giving play to its advantages in water quality monitoring and helping sewage treatment points to carry out accurate early warning. At the same time, with the in-depth research of cloud platform, the application research of water pollution early warning methods is also facing new opportunities and challenges.

1. Introduction

In recent years, cloud platform technology has been widely used in water quality detection. It has the advantages of fast and no secondary pollution, fingerprint detection, pollution traceability, etc., and has become the focus of current water quality detection research. Because the traditional water pollution early warning technology is used to deal with water pollution accidents, both the conventional stoichiometric method and the cloud-based data transmission are based on the traditional local area network, and the computing speed is relatively slow compared with the cloud server, which requires a large amount of time to carry out data transmission and evaluation, and is difficult to effectively solve the water pollution problem.

Many scholars have studied the early warning methods of water pollution. In Wang Yu's research, the sensor based on local plasma was developed for the detection of p-cresol, a water pollutant [1]. Wang Yubao studied and established an environmental complaint reporting system to monitor and manage industrial water pollution in a timely manner. Citizens can provide online and offline feedback on water pollution incidents and report human health risks [2]. Jenny Jean-Philippe believed that in a world with warming climate and increasing population, large lakes would need greater protection to achieve sustainable and high-quality water resources [3]. Wu Gaojie believed that the government and industry must also work together to strengthen the regulation of industrial emissions and strictly control pollution sources. The alternative emergency response mechanisms of different pollution sources were analyzed, which provided guidance for reducing pollution and provided a theoretical basis for establishing and improving water pollution management [4]. Rink Karsten believed that due to the extensive water pollution of rivers and lakes, it is necessary to vigorously improve the quality of drinking water and manage the sewage treatment process. For this purpose, a general workflow was proposed to integrate a large number of heterogeneous data sets related to different hydrological zones into the virtual geographic environment [5]. The purpose of Guo Gaimei's research was to evaluate the impact of water pollution accidents on human body and ecosystem, and use a new average absolute deviation calculation method to measure the model error [6]. The above studies have achieved good results, but with the continuous updating of technology, there are still some problems.

The water pollution early warning method based on cloud platform is studied. Lakshmikantha Varsha proposed a cost-effective intelligent water quality monitoring system based on the Internet of Things, which can continuously monitor water quality parameters [7]. Thai-Nghe Nguyen studied that these indicators of water quality are collected every day, and they become serial time series data. It was recommended to use deep learning with long-term short-term memory algorithm to predict these indicators [8]. Parameswari M believed that in this research process, the main contribution is to develop the security process of modern water quality monitoring system based on wireless sensor network [9]. Hossain SM Zakir has studied the basic concepts of biosensors and their applications in water quality monitoring, especially in online detection systems [10]. Dogo Eustace M believed that traditional machine learning technologies such as support vector machines, logical regression and artificial neural networks have been most frequently used in water quality anomaly detection tasks [11]. The above research shows that the application of cloud platform has a positive effect on water quality monitoring, but there are still some problems.

This paper studies the application research of water pollution early warning method based on cloud platform. First of all, the common monitoring technologies of water pollution early warning methods are analyzed, and then the relevant contents are given. The method research of cloud platform in water pollution early warning is analyzed. The relevant algorithms are used to provide theoretical basis for the experiment. Finally, the comparative analysis of the water pollution early warning system in a certain area before and after the experiment is carried out under the cloud platform, providing reference significance for such research.

2. Common Technologies of Water Pollution Early Warning Methods

The development process of water quality monitoring technology can be summarized as follows, as shown in Figure 1:

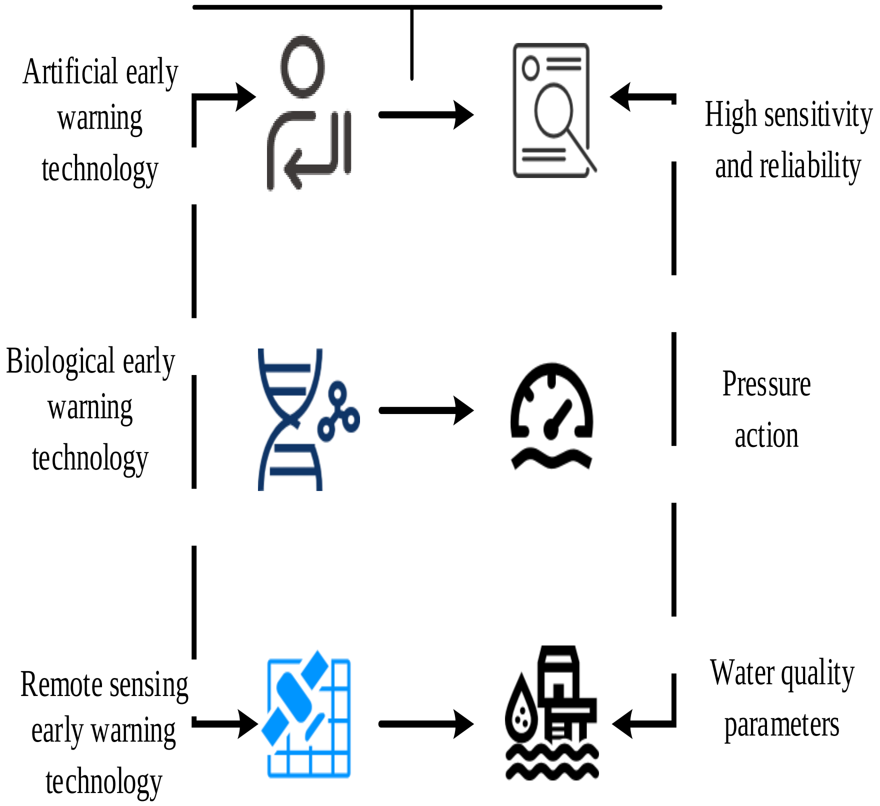


Figure 1. Common techniques used for water pollution early warning methods

2.1. Artificial Early Warning Technology

The artificial early warning technology is that the staff collect samples in a river and then conduct quantitative analysis in the laboratory. The portable measuring instrument is used for on-site measurement. This method is simple and fast, but due to the time limit, it cannot be transmitted to the monitoring center in real time and the manpower and material resources are limited.

Online water quality monitoring: this technology can detect and feedback water quality in real time. Most of the current online monitoring technologies have high sensitivity and reliability, but these technologies have their limitations, and each method is only applicable to a specific substance, which is difficult to achieve comprehensive early warning [12]. In recent years, with the improvement of scientific and technological level, various advanced detection methods have been widely used in water pollution early warning and gradually realized the tracking of water quality. However, these devices are often expensive and unstable, and it is difficult to promote them on large early warning platforms. Therefore, it is necessary to develop fast and accurate early warning technology, and strengthen the quantitative monitoring of certain pollutants and the quantitative monitoring of alternative indicators of pollution [13].

2.2. Biological Early Warning Technology

Biological early warning technology is to judge the toxicity of pollutants by the pressure between pollutants and organisms. All kinds of biological indicators have their advantages and disadvantages and are restricted by a variety of objective conditions. Relying on a single organism to carry out early warning often lacks reliability and accuracy. Looking for a comprehensive monitoring method with adaptability, economy and stability, and exploring the joint warning of multiple indicator organisms are the focus of future research. In order to reflect the hazards and superimposed effects of pollutants more comprehensively and accurately, it is necessary to further research and develop multiple biological integrated early warning technologies to improve their accuracy and comprehensiveness.

2.3. Remote Sensing Early Warning Technology

Remote sensing technology uses the correlation between satellite remote sensing data and water quality parameters. The following is an analysis of various remote sensing technologies, as shown in Figure 2:

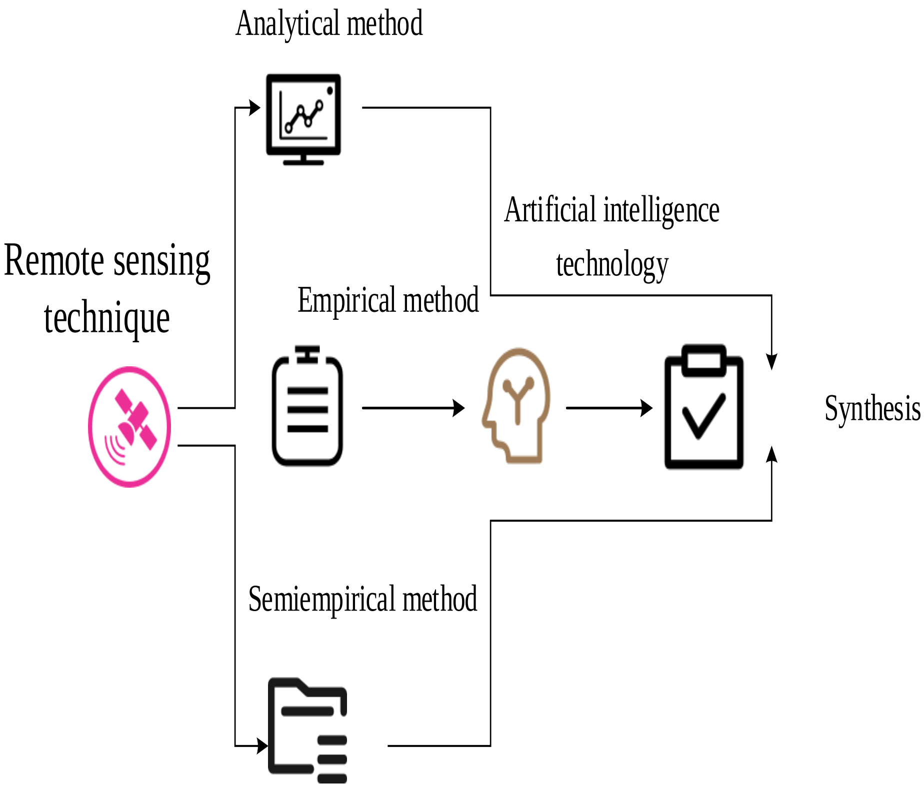


Figure 2. Analysis of various remote sensing technologies

2.3.1. Analytical Method

The analytical method is to study the transmission of light in the atmosphere and water body and calculate the corresponding water quality parameters according to the reflectance measured by remote sensing to determine the relationship between them and water quality parameters [14]. This method has good stability and does not need a lot of ground observation data as a basis. However, on the basis of known spectral characteristics of water quality parameters in the water body, the observed water body must be measured with corresponding auto-optical and apparent optical quantities during the modeling process.

2.3.2. Empirical Method

By correlating remote sensing data with ground observation data, the empirical method selects the frequency band with high correlation for statistical analysis, thus obtaining the optimal inversion model of water quality parameters, which improves the accuracy of inversion to some extent. However, empirical methods are not universal due to geographical, time and other factors. In order to obtain better inversion accuracy, a large number of observation data must be supported. Under the influence of the actual observation data, only the water quality parameters of a certain concentration can be retrieved, and the accuracy of the retrieved results would have a large deviation beyond this value, so the accuracy of the model is difficult to guarantee.

2.3.3. Semiempirical Method

The semi-empirical method uses the correlation between the water quality spectrum characteristics and the actual observation data, selects the appropriate frequency band or frequency band combination, and selects the appropriate mathematical statistical model for inversion. It makes full use of the spectral characteristics of water, and is the most commonly used one at present. However, due to the time and space limitations of the semi-empirical method, it is necessary to analyze the water bodies of different types, different regions and different seasons, and establish corresponding mathematical models to improve their universality.

2.3.4. Artificial Intelligence Technology

In recent years, with the development of artificial intelligence technology, many new research results have emerged in the field of water quality monitoring. Because the spectral characteristics of water bodies are very complex, the application of remote sensing technology to water quality monitoring is a very effective method. Through continuous learning and correction of data, the complex relationship between remote sensing data and water quality data can be well handled. Using machine learning technology in water quality remote sensing monitoring can obtain better results, but due to the need for a large number of training samples, the corrected parameters would also lead to the extension of the training time of the model. Therefore, how to find a balance between complexity and computational efficiency is critical.

2.3.5. Comprehensive Method

The traditional remote sensing technology has certain limitations due to the influence of physical characteristics and composition of water body. The comprehensive method is a comprehensive use of various remote sensing technologies and makes full use of the advantages of these methods, thus improving the accuracy and versatility of inversion.

At present, the use of remote sensing technology for water quality monitoring has been developed to some extent, and there are many models, but its adaptive ability, incomplete indicators and low accuracy need to be further improved. At present, the spectral characteristics of single parameter are relatively clear, but due to the complex composition of water body and the interaction of various water quality indicators, there is a coupling relationship between its spectral curve and various water quality indicators.

3. Evaluation on Methods of Cloud Platform in Water Pollution Early Warning

The purpose of this paper is to explore a new method to realize water pollution early warning using cloud computing platform and apply it to the online early warning of water pollution. Using portable automatic monitoring devices scattered all over the river, the monitoring data would be transmitted to the cloud server through the network, and the standard model would be established according to different river flow monitoring points. The spectrum data measured by the water quality monitoring instruments at each monitoring station would be converted into high-precision water quality monitoring instruments, and a standardized database would be established. At the same time, the water quality spectral data is extracted by using the deep learning technology. The network model is trained and the water quality parameter analysis model is established. The water quality data is processed, identified and classified on the cloud computing server, and the classification is displayed in real time. According to the monitoring results, the river reaches beyond the critical point are selected to realize the water pollution early warning based on cloud computing.

After the water quality is collected, the water quality data in the visible band is standardized, so that different water quality collection devices are standardized to achieve the transmission of the model, reducing the financial and material resources of the instrument, and improving the use efficiency of the model. Therefore, a standardized band water quality database is established for standard equipment. In the process of collection, according to the different indexes and parameters of different river sections, different types of categories are determined and appropriate network models are selected. The water quality data of the bands are extracted by the deep learning method, and the classification of the visible wave band is realized by learning and training the water quality bands of the same category.

Using this model, based on the cloud platform big data and cloud computing technology, combined with the efficient computing ability and portability, the water quality data processing is completed on the cloud, and on this basis, the water quality monitoring and early warning system is established to monitor the water in real time to achieve the purpose of water pollution early warning.

4. Cloud Computing in Water Pollution Early Warning

The exponentially weighted moving average method is an exponentially weighted average motion calculation method. This method can make the short-term waveform stable, maintain the long-term change trend of the waveform, use the weighted coefficient method for maximum likelihood estimation, obtain higher observed visible water spectrum data, and restore the theoretical water quality spectrum data under the maximum possible conditions.

$$E(N) = \lambda Y(N) + (1-\lambda)E(N-i) \tag{1}$$

At band point N, E(N) is the estimation of spectrum data; Y(N) is the spectrum data measured at the band point N. If it is a weighting coefficient, then 0<N<1, and it decreases exponentially with the increase of the number of N.

Direct normalization principle: the matrix of source random interpolation is defined as L_m object and L_t, and the matrix of L_m and L_t is constructed by F transformation matrix.

$$L_m = L_t F \tag{2}$$

Here, L_t^+ is the generalized inverse matrix of L_t, so the transformation matrix F can be obtained:

$$L = L_t^+ * L_m \tag{3}$$

The target machine matrix L_t is transformed into L_m through the transformation matrix L. It can be seen from this result that if the target instrument is used to detect the unknown sample, its spectral moment can be converted into the spectrum of the source equipment for the unknown sample. Therefore, in theory, the spectrum matrix of the source equipment should be the same as the three values:

Standardization is to change the average value of each characteristic in the spectral data to 0, and the standard value to 1. If it exceeds this value, it would return to L^*, which is the average value of all the absorption rate data, and σ represents the standard deviation of the absorption rate data:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i1}^{N}(L_i - \mu)^2} \tag{4}$$

$$L^* = \frac{L-\mu}{\sigma} \tag{5}$$

$$L^* = \frac{L^* - L_{\min}^*}{L_{\max}^* - L_{\min}^*} \tag{6}$$

When the absorbance value is mapped to [0~1], the data is normalized.

5. Comparative Evaluation to Different Water Pollution Early Warning Methods

Water pollution early warning is to study the change trend and possible impact of water quality composition analysis or historical data analysis. At present, the commonly used water resources pollution and early warning methods can be roughly divided into the following two categories: one is the water quality model established by studying the changes of river composition and water quality parameters; the other is the early warning system built by means of multi-technology. In this paper, the water pollution early warning system based on cloud platform is studied. The establishment of a cloud-based water pollution early warning system can cope with the rapid changes in the current water environment, save computing time, and protect the environment and the formulation of the next pollution treatment policy.

Two Cities X and Y in a certain region were randomly selected. With the rapid development of the economy, these two cities are more and more controlled by some local industrial enterprises. Because these enterprises consume a large amount of water, resulting in a large amount of sewage discharged during their production process, some enterprises would have problems such as non-standard sewage treatment, resulting in the increasing water pollution in the region. Therefore, through comparative analysis of Cities X and Y, Table 1 shows the treatment capacity and quantity statistics of sewage treatment points in the region from 2018 to 2022.

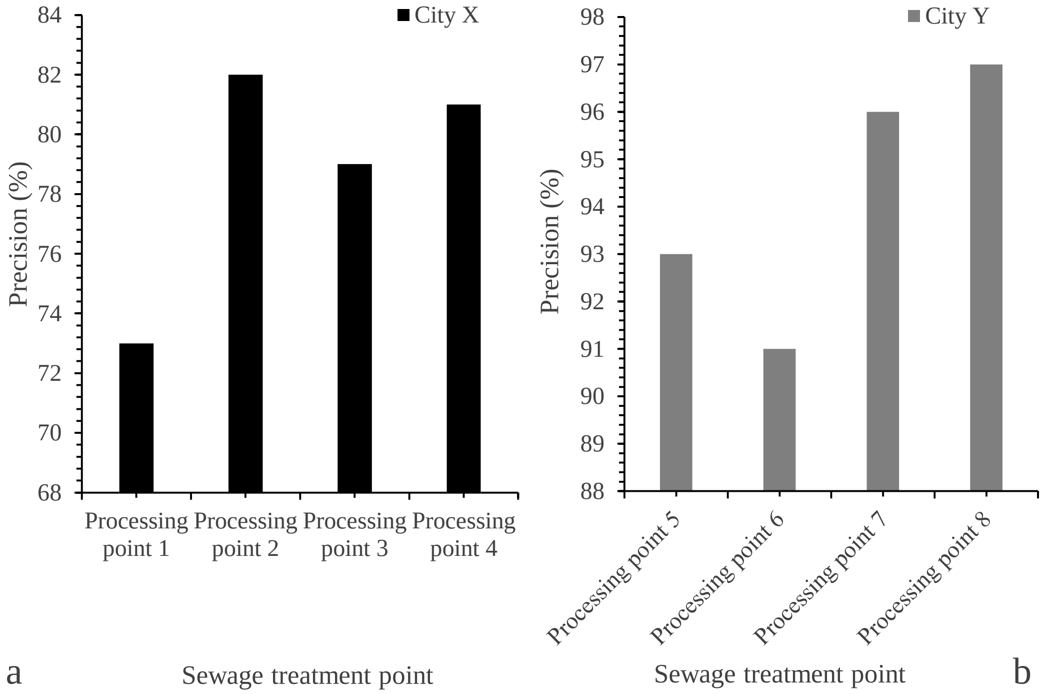
It can be seen from Table 1 that the sewage treatment capacity and the number of sewage treatment points in this area wre increasing over time in 2018-2022. Among them, the treatment capacity in 2019 has increased by about 7% compared with that in 2018; the treatment capacity in 2020 has increased by about 4.3% compared with that in 2019; the treatment capacity in 2021 has increased by about 4.7% compared with that in 2020; the treatment capacity in 2022 has increased by about 15.6% compared with that in 2021. It can be seen that the sewage treatment capacity in this region in 2018-2021 has been rising, but the overall growth rate has shown a downward trend.

However, the growth rate in 2021-2022 would pick up, which may be due to the impact of the environment.

Table 1. Statistics of the treatment capacity and quantity of sewage treatment points in this region

	Processing capacity (ton)	Number of sewage treatment points
2018	17526	654
2019	18745	751
2020	19542	821
2021	20463	903
2022	23647	957

First, based on the above content analysis, the two types of water resources pollution and early warning methods were analyzed. Among them, City X used the water pollution early warning system established by the changes of river composition and water quality parameters, while City Y used the water pollution early warning system established by the cloud platform to compare the water pollution early warning systems established by the two cities, as shown in Figure 3:



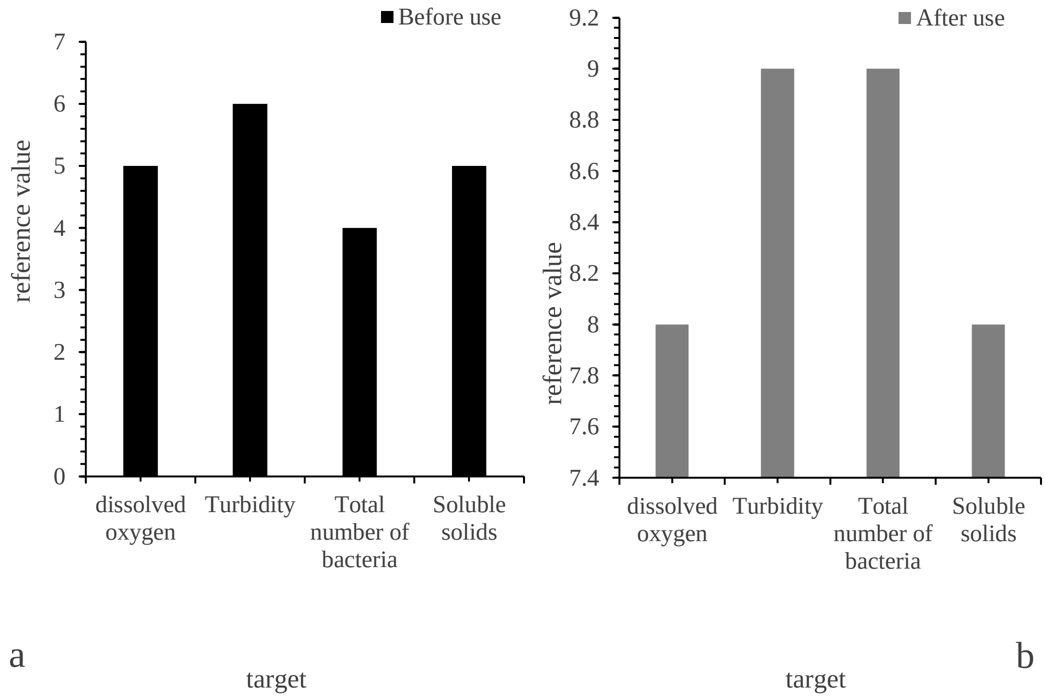
a. Precision of the processing point system in the city X

b. Precision of the processing point system in the city Y

Figure 3. Precision of the processing point system in the two cities

Figure 3a shows the accuracy of the sewage treatment points of the water pollution early warning system established by the change of river composition and water quality parameters in City X, and Figure 3b shows the accuracy of the water pollution early warning system established based on the cloud platform in City Y. It can be seen from Figure 3 that the accuracy of the four sewage treatment point systems in City X was between 70 and 90, of which the early warning accuracy of the treatment point 1 system was the lowest and the treatment point 2 system was the highest. The accuracy of the four sewage treatment point systems in City Y was above 90, of which the early warning accuracy of the treatment point 6 system was the lowest and the treatment point 8 system was the highest.

It can be seen from this that the water pollution early warning system based on cloud platform had high accuracy and was more suitable for dealing with water pollution problems in this area. City Y was taken as an example to analyze the change of water quality before and after using the system. The indicators were PH value, turbidity, total bacterial count and dissolved solids, and the reference values of these indicators were counted, as shown in Figure 4:



a. Reference values of the indicators before use

b. Reference values of the indicators after use

Figure 4. Reference values of indicators before and after use

Figure 4a shows the reference values of the four indicators of water quality before use, and Figure 4b shows the reference values of the four indicators of water quality after use. It can be seen from Figure 4 that the difference between the reference values of dissolved oxygen, turbidity and dissolved solids before and after use in the city was 3, while the difference between the reference values of total bacterial count before and after use was 5.

According to the description of the above data, the water pollution early warning system established by City Y based on the cloud platform is conducive to giving play to its advantages in water quality monitoring and helping sewage treatment points to carry out accurate early warning.

6. Conclusion

At present, there are serious water pollution problems in many places, and the discharge of some pollutants has exceeded the capacity of the environment, posing a serious threat to people's health, social stability and environmental security. Especially for sudden water pollution accidents, the causes are complex and difficult to determine due to different pollutant discharge modes, different discharge routes, different time and different locations. On this basis, combined with the accuracy of the sewage early warning system of the two cities, representative cities were selected and water quality monitoring was carried out. It can be seen that the water pollution early warning system based on cloud platform is more practical in water quality 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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