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Construction of Urban Water Source Circulating Water Pollution Prevention System Based on Semi-supervised Learning and Bayesian Algorithm

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Keywords: Urban Water Cycle, Water Pollution Prevention, Semi-supervised Learning, Bayesian Algorithm

Abstract: Drinking water safety is directly related to public health. Urban water sources must maintain people's life and social stability in the event of major accidents. In building a welfare society, the realization of social harmony is the basic guarantee for urban water supply, emergency preparedness, social stability and sustainable development of the city. The urban water cycle is managed by a large amount of cooling water. However, with the current intensive water supply, the water quality has gradually deteriorated. In particular, surface water contains various pollutants, including inorganic matter, organic matter, dissolved matter and suspended matter, which have a certain impact on metal or non-metallic substances in the system. On the one hand, scale or dirt is formed on the surface of the heat exchanger, which reduces the overall efficiency of the system and increases the resistance. On the other hand, it directly corrodes the metal materials of the cooling water system, which even affects the quality of the condensate water, and threatens the safe operation of the boiler. Therefore, the prevention of the pollution of urban circulating water system is a very important work. Semi-supervised learning and Bayesian algorithm have played an excellent role in water pollution control. This paper applied this algorithm to the construction of urban water source circulating water pollution prevention system. Finally, it was concluded that the removal rate of suspended solids could be greatly improved by adopting the urban water source circulating water pollution prevention system. The elimination rate of total nitrogen was 31.4% higher than that before using the urban water source circulating water pollution prevention system, thus effectively preventing and controlling water pollution.

1. Introduction

Water pollution is widely concerned by the public at present, and there is a good application

space for its prevention and control because of the harm it causes to human body. The urban water source cycle is closely related to the public's life, and the water pollution incident caused by it has become the top priority of public concern. Semi-supervised learning and Bayesian algorithm have great application in water pollution prevention and control. However, few people have studied this field. Based on this, it is necessary to analyze the urban water source circulating water pollution prevention system.

At present, water cycle is widely concerned by scholars, and some scholars praise and analyze it. Liu, Zhihua shared the decision-making behavior of different participants in industrial water recycling and the value of reclaimed water recycling, and put forward a decision-making model for industrial water recycling. The cooperation between reclaimed water users and professional suppliers could create surplus value [1]. Nemeroff, Carol reviewed the principles related to understanding and improving the acceptance of urban circulating water in decision-making psychology. He surveyed 2680 respondents from five cities in the United States and identified the basic psychological characteristics that affected the resistance to circulating water [2]. Nkhoma, Peter R studied the public's views and attitudes towards water reuse around the world, and found that the research results of water reuse acceptance were often specific. Although it could be claimed that some prediction factors were generally relevant, he stressed that individual water reuse plans needed to carefully consider their local background [3]. Hess, David J investigated the utilization degree mode of two main indirect uses of circulating water: double network system and groundwater recharge [4]. Ding, Yizhe analyzed the relationship between urban residents' feelings for reclaimed water and public acceptance [5]. Greenaway, Tameika's research found that positive emotional information framework could reduce risk perception and improve acceptance of circulating water [6]. Archer, Jana E analyzed the spatial patterns of recycled water use in Florida and California in 2009 to detect distribution gaps and identify potential expansion areas [7]. The investigation and analysis of the water cycle have few problems about its pollution.

The frequent occurrence of water pollution incidents has caused public concern. Oral, Hasan Volkan reviewed the natural-based urban water management solutions for European recycling cities [8]. Morin-Crini, Nadia reviewed water pollution cases of emerging pollutants worldwide [9]. Li, Z. H. O. U studied China's river director system and agricultural non-point source water pollution control [10]. He, Xiaodong analyzed the surface water pollution of the loess plateau in central China [11]. Tan, Poh-Ling analyzed the governance factors affecting the diffuse water pollution of the Great Barrier Reef in Australia [12]. Tang, Yankui studied the emerging pollutants in the water environment [13]. Sarker, Bijoyee studied surface and groundwater pollution and analyzed the causes and impacts of urbanization and industrialization in South Asia [14]. Urban water pollution plays an important role for residents living in cities. However, no one has yet applied semi-supervised learning and Bayesian algorithm to water pollution prevention.

In order to improve the prevention and control effect of urban water source circulating water pollution, this paper used semi-supervised learning and Bayesian algorithm to build the urban water source circulating water pollution prevention and control system. Firstly, the urban water source cycle was introduced, and then the current situation and legal issues of urban water pollution were analyzed. Then, Bayesian algorithm and semi-supervised learning algorithm were introduced, which were used to build the urban water source circulating water pollution prevention system. Finally, the control effect of the urban water source circulating water pollution control system was analyzed. Finally, it was concluded that the removal rate of suspended solids could be greatly improved by adopting the urban water source circulating water pollution prevention system. Compared with other people's experimental results, this paper combined semi-supervised learning and Bayesian algorithm, and applied them to water pollution prevention.

2. Urban Water Source Circulation

Urban water cycle is a kind of artificial water cycle. Human beings continuously use groundwater or surface water to meet the needs of life and production activities in the natural water cycle. For example, cities take water from natural water bodies and treat it for industrial, commercial, municipal and household purposes. The used wastewater is discharged to the treatment plant through the sewage treatment system, and then returned to the natural water body after treatment. In short, the urban water system is the urban water supply and wastewater system. Urban water cycle includes water intake point, water supply and wastewater treatment plant, urban water supply network, water facilities, drainage system, sewage network and wastewater treatment.

Urban development has directly or indirectly changed the natural process of water environment and water cycle. Large areas of natural vegetation and soil have been replaced by modern buildings and structures, increasing the impermeable surface area, thus reducing the infiltration of precipitation and changing the evaporation conditions in natural areas. Urban water cycle should follow the natural law of water cycle. For the consideration of sustainable economic and social development, many places have conducted in-depth research on the impact of urbanization on urban water cycle elements. In some areas, scientific response measures have been taken. A strong urban water circulation system has been established to improve the capacity of urban water resources and water environment and promote the sustainable development of the city.

The urban water cycle is closely related to the life of residents, including all aspects of human life. When water pollution occurs in the urban water cycle, it causes serious harm to human body. When the pH value of water decreases, the sulfate concentration increases and the corrosivity increases. Especially when the pH value drops abnormally, it poses a direct threat to the circulating water system, resulting in a decrease in the heat exchange capacity of the heat exchanger and an increase in energy consumption. At the same time, with the increase of the use of cold water exchange equipment, the corrosion rate continues to increase, and the wall thickness of the water cooler becomes thinner and thinner, resulting in damage or perforation, which poses a great threat to the normal production of the equipment. At the same time, it also has adverse effects on sterilization of circulating water system.

3. Current Situation and Legal Issues of Urban Water Pollution

3.1. Current Situation of Urban Water Pollution

Water pollution refers to the pollution of water bodies by land-based sources. The substances or energy discharged into the water body from terrestrial sources due to human production and living activities lead to changes in the chemical, physical, biological or radiation properties of the water body, resulting in deterioration of water quality. This affects the effective use of surface water, endangers human health or damages the ecological environment [15-16]. These polluted water bodies can recover the water quality through self-treatment to meet people's wastewater demand. However, with the development of modern industry and urbanization, the amount of waste water generated by human beings has increased sharply, which exceeds the capacity of water bodies, leading to serious water pollution problems and water shortage in cities.

3.2. Legal Problems of Urban Water Pollution

The main reason for urban water pollution and urban water ecological pollution is that urban residents engaged in economic activities do not equate the production function of the ecological environment (providing water resources, etc.) with the maintenance function. The result is that the

conflicts and contradictions between the two functions are increasingly manifested, which eventually leads to the deterioration of the interaction between the two functions. However, the use and improvement of water resources as public goods can benefit some people without affecting the survival and optimization of others, which undoubtedly benefits most people. It is difficult to achieve the expected results in the prevention and control of urban water pollution.

Urban water pollution mainly includes industrial wastewater and urban domestic wastewater, which can be discharged in point or surface form. The causes of urban water pollution can be divided into two categories: institutional and behavioral, which depend on the pollution process and the damage to aquatic ecosystems. At present, the focus of urban water pollution prevention and control is to control point source pollution and improve the legal system. Although there are relevant laws and regulations as well as some ministerial and local decrees that have established a legal system framework for water pollution prevention and control on the macro level, the impact on the micro level of implementation is very limited, especially in the following cases, as shown in Figure 1.

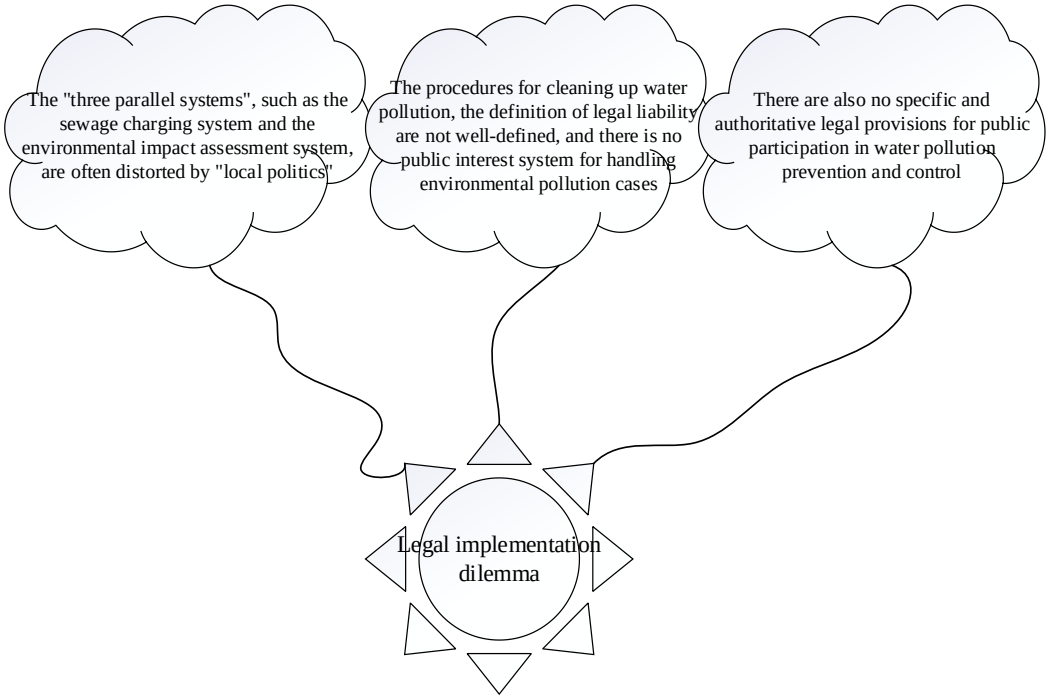


Figure 1. Legal implementation dilemma

The “three parallel systems” such as sewage charging system and environmental impact assessment system are often distorted by “local politics”. In order to maintain the punishment for the ongoing behavior, the local government hopes to clean up through large-scale polluting enterprises, but does not supervise the impact of subsequent cleaning up. The procedures for cleaning up water pollution and the definition of legal liability are not perfect. There is no public welfare system to deal with environmental pollution cases, and there is no specific and authoritative legal provisions for public participation in water pollution prevention. Therefore, the handling of water pollution cases is mainly limited to government coordination. At present, the legal liability for water pollution is limited to enterprises and individuals, with the focus on state-owned enterprises and high-polluting enterprises. They only bear administrative responsibility for water pollution caused by the activities of public authorities. There is no provision for civil liability for water pollution, the scope and extent of compensation, and the proportion of damage caused is severely

unbalanced.

4. Bayesian Algorithm and Semi-supervised Learning

4.1. Naive Bayesian Classifier

Naive Bayesian classifier is one of the most widely used Bayesian classification models. The model is described as follows. It is supposed that the training set contains a class.

$$G = \{G_1, G_2, \Lambda\ , G_a\} \tag{1}$$

b is a conditional feature.

$$H = \{H_1, H_2, \Lambda\ , H_b\} \tag{2}$$

It is assumed that all food attribute H is considered as a subset of class variable G.

According to Bayesian theorem. The posterior probability of Gj class is:

$$p(G_j|H) = \frac{p(G_j)p(H|G_j)}{p(H)} \tag{3}$$

If the probability of a class in a group of words is unknown in advance, it can be assumed that the probability of each class is equal, and $p(G_i|H)$ reaches the maximum.

$$p(G_j|H) = \frac{p(G_j)p(H|G_j)}{p(H)} \propto p(G_j)p(H|G_j) \tag{4}$$

$$p(G_j) = M_j / M \tag{5}$$

In the formulas: Mj is the number of instances in the training samples, and M is the total number of training samples.

Naive Bayesian classification algorithm deals with data sets with different data characteristics, and the classification results vary little and are relatively stable. In the case of missing data, the algorithm improves the integrity of data through preprocessing. The naive Bayesian classification algorithm obtains the prior probability of the class and the conditional probability of the symptom class from the training set to predict the posterior probability. Then, a formula is used to obtain the class spectrum of cases to be classified. The distribution of the limited training data set cannot fully reflect the distribution of the overall situation, so the confidence of the estimated prior probability needs to be adjusted. If the integrity of the training set is not good, the accuracy of the prediction label of the test data may be reduced.

4.2. Semi-supervised Learning

Semi-supervised learning in pattern recognition uses a large number of data without class tags and data with class tags at the same time. Because the traditional naive Bayesian classification algorithm uses training sets with class labels to predict the categories of data in the test set. Therefore, Formula (4) is replaced by:

$$p(G_j|H) = \max\ p(G_j)(x+y)\sum_{j=1}^{m} p(H_j|G_j)(x+y) \tag{6}$$

Semi-supervised learning requires fewer people and provides relatively high accuracy. Therefore, people are more and more interested in semi-directed learning, but semi-supervised learning algorithm has great problems. The combination of semi-supervised learning and naive Bayes is used to classify a large number of data with unknown class labels. The basic principle of semi-supervised learning is to establish an initial classifier based on a small number of training instances with class markers. Each time, the classifier can actively select the best instance from the candidate set without class tags, and incorporate these instances into the training set with class tags in some way, while continuing to train the classifier. By adding these examples to the training set with class markers, the classifier is further trained.

5. Urban Water Source Circulating Water Pollution Prevention System

5.1. Prevention Requirements

The water pollution prevention and control system is designed from a macro perspective, including three links: protecting and saving water resources, controlling water and wastewater pollution sources, wastewater treatment and river recycling. A regional water pollution prevention and control system has been gradually established in the city. From the perspective of pollution treatment and control, the water pollution prevention and control system mainly includes six measures: (1) adhere to the water quality control of the water supply part; (2) adjust industrial structure and implement cleaner production; (3) discharge of pollution sources up to standard; (4) improve control measures and implement clean sewage circulation; (5) centralized treatment of urban sewage (development zone); (6) sewage source treatment. These six measures can be comprehensively applied to control the trend of rapid deterioration of the overall water environment, and achieve the goals set by the state, so as to meet the needs of large-scale economic development in areas with serious water shortage. These six measures can be summarized in Figure 2.

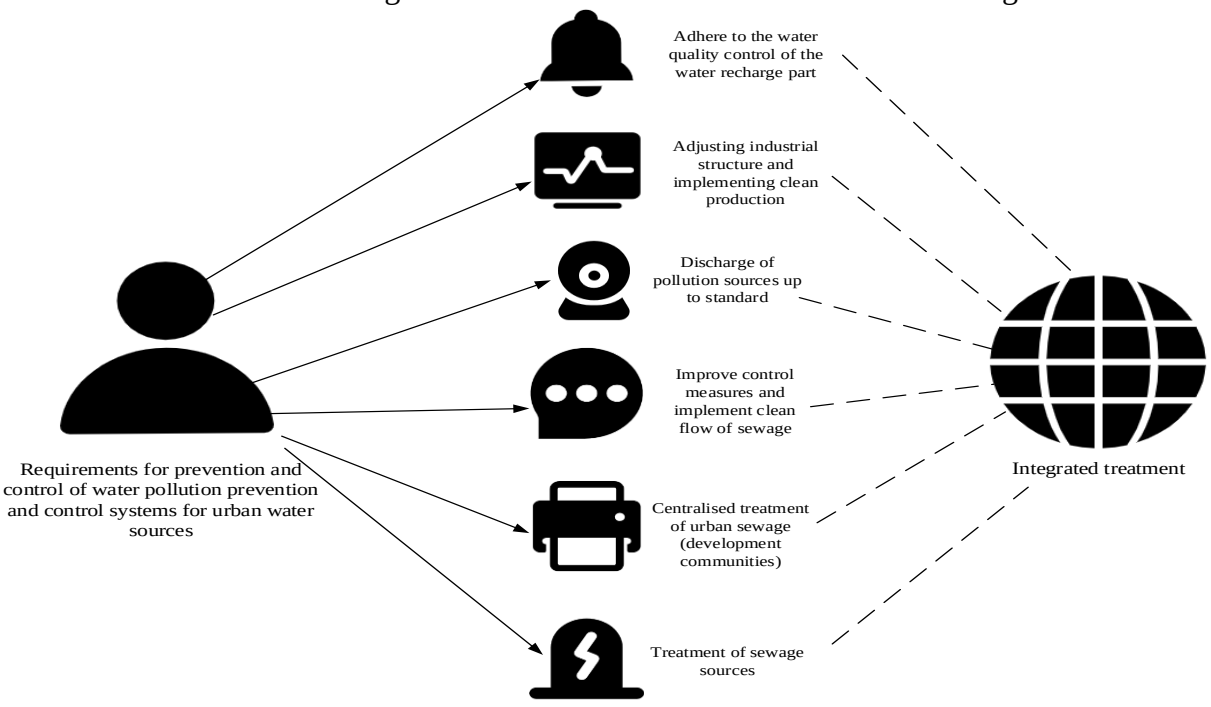


Figure 2. Requirements for prevention and control of water pollution prevention and control systems for urban water sources

5.2. Main Components

The main components of the urban water source circulating water pollution prevention system are recorded in Figure 3.

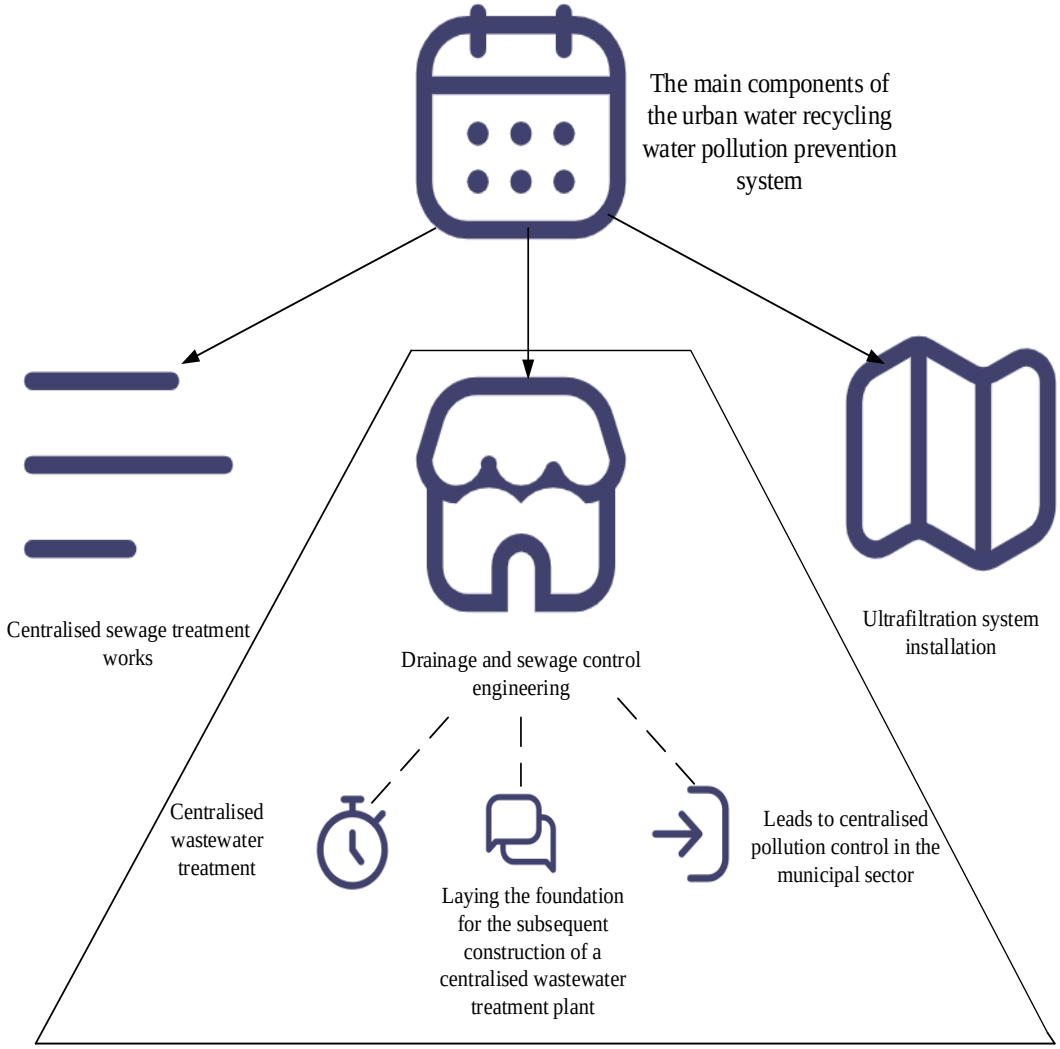


Figure 3. The main components of the urban water recycling water pollution prevention system

5.2.1. Centralized Sewage Treatment Project

In the cycle of urban water pollution prevention and control system, centralized sewage treatment plant not only is a device to reduce pollution load, but also can improve the water quality of sewage flow to meet the water quality standard of agricultural irrigation, which is the most important measure to control the deteriorating trend of agricultural ecological environment.

5.2.2. Drainage and Sewage Control Works

The control measures can be river drainage wastewater or seasonal control reservoir. This control measure can centrally treat wastewater and restore the function of most rivers. As the first step of centralized wastewater treatment, it lays the foundation for the subsequent construction of centralized wastewater treatment plants. The municipal industry is guided to centralize pollution

control. The regulatory measures for the governance of the central area and lakes have been basically completed, but there are still problems in the regulation of rivers. The treatment project in the new stage needs to take into account the natural characteristics of the local water environment and the distribution of pollution sources to design in a unified way and reasonably determine the water outlet direction, so as to properly adjust the upstream and downstream relationship. Rural water resources protection and well drilling projects mainly involve pollution along the water diversion line, water and soil loss in the water source basin, and nitrogen and phosphorus pollution in the reservoir. Water resources protection mainly refers to the protection of agricultural water.

5.2.3. Ultrafiltration System Device

The ultrafiltration system adopts submersible ultrafiltration. Self-cleaning filter is installed at the upstream of submerged ultrafiltration. Discharge tank, backwashing tank, treatment tank, backwashing pump and treatment pump are installed, which are used for daily washing, maintenance, cleaning and recovery of ultrafiltration system. The ultrafiltration system shall be equipped with metering devices for sodium hypochlorite, sodium hydroxide and hydrochloric acid.

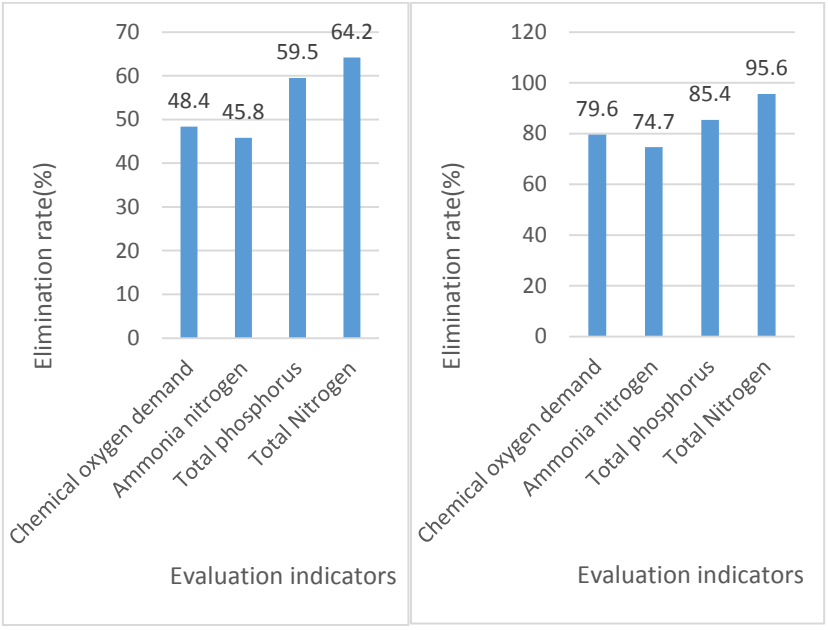
6. Prevention and Control Effect of Urban Water Source Circulating Water Pollution Prevention and Control System

In this paper, the urban water source circulating water pollution prevention system was used to prevent and control the water pollution generated in the urban water source circulation. In order to make the experimental results accurate and effective, this paper selected the water intake of the urban water source circulation to monitor the water quality using the urban water source circulation water pollution prevention system. The selected indicators are recorded in Table 1.

Table 1. Water pollution evaluation indicators

Evaluation indicators	Interpretation
Chemical oxygen demand	The amount of reducing substances in a water sample that need to be oxidised, measured chemically under certain conditions
Ammonia nitrogen	Chemically combined nitrogen in the form of ammonia or ammonium ions
Total phosphorus	The result of the conversion of various forms of phosphorus into orthophosphate after the water sample has been digested
Total Nitrogen	The sum of nitrogen present in inorganic and organic forms

The survey results of the elimination rate of COD, ammonia nitrogen, total phosphorus and total nitrogen measured by the urban water source circulating water pollution control system are recorded in Figure 4.



A. Effectiveness of control before the introduction of the urban water recycling water pollution control system

B. Prevention and control effect after the introduction of the urban water recycling system

Figure 4. Prevention and control effect before and after the adoption of urban water recycling system

In Figure 4, A represents the prevention and control effect before adopting the urban water source circulating water pollution prevention and control system, and B represents the prevention and control effect after adopting the urban water source circulating water pollution prevention and control system. Before adopting the urban water source circulating water pollution control system, the elimination rate of chemical oxygen demand was 48.4%, and the elimination rate of ammonia nitrogen was 45.8%. The elimination rate of total phosphorus was 59.5%, and the elimination rate of total nitrogen was 64.2%. However, after adopting the urban water source circulating water pollution control system, the elimination rate of chemical oxygen demand was 79.6%, which was 31.2% higher than that before adopting the urban water source circulating water pollution control system. The elimination rate of ammonia nitrogen was 74.7%, which was 28.9% higher than that before using the urban water source circulating water pollution control system. The removal rate of total phosphorus was 85.4%, which was 25.9% higher than that before using the urban water source circulating water pollution control system. The removal rate of total nitrogen was 95.6%, which was 31.4% higher than that before the use of urban water source circulating water pollution control system. By comparison, the removal rate of suspended solids can be greatly improved by adopting the urban water source circulating water pollution prevention system, thus effectively preventing and controlling water pollution. It can be seen that the use of urban water source circulating water pollution prevention and control system has an excellent effect on water pollution prevention and control.

7. Conclusion

In order to improve the pollution prevention and control effect of urban water cycle, this paper

used semi-supervised learning and Bayesian algorithm to build the urban water cycle pollution prevention and control system. The water pollution control effect of the system was analyzed. The elimination rate of chemical oxygen demand, ammonia nitrogen, total phosphorus and total nitrogen was selected as the reference index, and finally the feasibility conclusion was reached. After adopting the urban water source circulating water pollution control system, the water pollution control effect of urban water circulation has been greatly improved. Semi-supervised learning and Bayesian algorithm have excellent control effect in water pollution control, and this technology can be applied to water pollution control in the future.

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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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