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Exploration on Risk Assessment of Water Pollution Prevention and Control Based on Fuzzy Bayesian Network

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Abstract: With the acceleration of industrialization, modernization of agriculture and animal husbandry and urbanization, the pressure of water environment and water pollution are also increasingly prominent. However, agriculture, industry, service industry and the whole society have an increasing demand for water resources, and the contradiction of water resources shortage is also increasingly obvious. In this case, although some water pollution (WP) prevention measures have been put forward, there are still some risks in WP prevention. In this regard, this paper studied the risk factors and evaluation of WP prevention and control based on the fuzzy Bayesian network. It put forward the prevention and control risk factors such as the risk of pollution prevention and control laws and regulations, the risk of prevention and control management mechanism, and evaluated and studied the risk levels of WP prevention and control in the three urban areas of Z City. The results showed that the risk index of WP prevention and control in D, X and Q districts was 45.9, 51.5 and 49.3 respectively from the perspective of average value, and the risk level of the three urban areas was acceptable; from the perspective of fuzzy Bayesian network, the risk level of WP prevention and control in D, X and Q areas also belonged to the acceptable risk level.

1. Introduction

At this stage, people have been faced with a very serious water resource problem, and the prevention and control of WP has gradually received people's attention. Effective prevention and control of WP is of great significance for alleviating and solving the problem of WP, ensuring the safety of industrial water and agricultural water, and ensuring the safety of people's domestic water.

Bayesian networks can express causal relationships naturally and effectively, and can mine their internal relations and laws from data sets. In this paper, the risk prevention of WP is studied by using fuzzy Bayesian network.

Many scholars have studied WP and its control. Ge Simin investigated the distribution characteristics of microcystins in drinking water sources in seven major watersheds, and discussed the harm that this toxin can cause to human body in water and the effect of drinking water treatment institutions in treating this toxin [1]. Wu Gaojie collected a large number of WP events through traditional media channels and network channels, and made in-depth analysis of these events according to the occurrence characteristics of WP events. He put forward emergency handling technology and emergency management suggestions [2]. Wang Yubao applied some statistical methods to WP event feedback to promote relevant departments to prevent and control WP caused by factories [3]. Kumar Vinod evaluated and demonstrated the WP situation of the Indus River, the Bis River, the Sutraiji River and the Harik Wetland. He analyzed a large number of water quality data through multiple statistical techniques, and compared them using the public WP index [4]. Wu Liang reviewed the impact of drinking water quality and pollutants on human cancer incidence. In his research, he showed that the improvement of drinking water quality can reduce the incidence of cancer in the human digestive system [5].

In addition, Li Xinyan put forward an underground WP risk assessment method that considers both in-situ and mining value after comprehensively considering the hazard of pollutants, potential risk factors of pollutants and the possibility of occurrence of risk factors [6] . Zhang Jinde explored the water and soil environment of a mine and analyzed the risk factors and characteristics of WP [7]. Luhao L Y U gave a detailed introduction to the pollution status, environmental behavior and toxic effects of antiviral drugs in water, and put forward his own views on how to effectively control the application of antiviral drugs in water environment [8]. He Xiaodong studied the surface water, spring water and other water bodies in a plateau, and analyzed some factors affecting the surface WP [9]. Radfard Majid analyzed the content level of various pollutants in drinking water, and analyzed the harm caused by high content of pollutants [10]. All the above scholars have carried out research on WP and its prevention and control, and put forward valuable suggestions.

In order to protect and maintain the health of water resources, ensure the safety of water use in industry, agriculture and other industries, and ensure the ecological balance and people's health, this paper put forward the risk factors of WP prevention and control, including regulatory risk, management mechanism risk, financial support risk, water resources development risk and WP prevention and control technology risk, and used fuzzy Bayesian network to evaluate and study the risk factors of WP prevention and control. Compared with other studies, this paper studied the prevention and control risk of WP based on fuzzy Bayesian network instead of WP risk.

2. Hazards and Factors of Water Pollution

2.1. Hazards of Water Pollution

This paper summarized the hazards of water pollution, as shown in Figure 1.

Agricultural water: water resources are used for agriculture after being polluted. After the water source is polluted, it would produce a large amount of heavy metals and other poisons. If it is used to irrigate farmland for a long time, it would not only cause serious damage to the soil, but also have a negative impact on the growth of crops, and even endanger human health. Industrial water: industrial development cannot be separated from a large number of water resources. However, if the water resource contains a large amount of impurities, it would damage the equipment. In addition, new chemical components are often produced in industrial production. If these chemical components react with raw materials, it would have a great impact on the quality of products.

Physical health: water is one of the most important substances needed by the body, and it is also a component of the body. In order to obtain substances beneficial to the body, human beings must ingest a large amount of healthy water. If the water source is polluted, it would pose a great threat to human health [11].

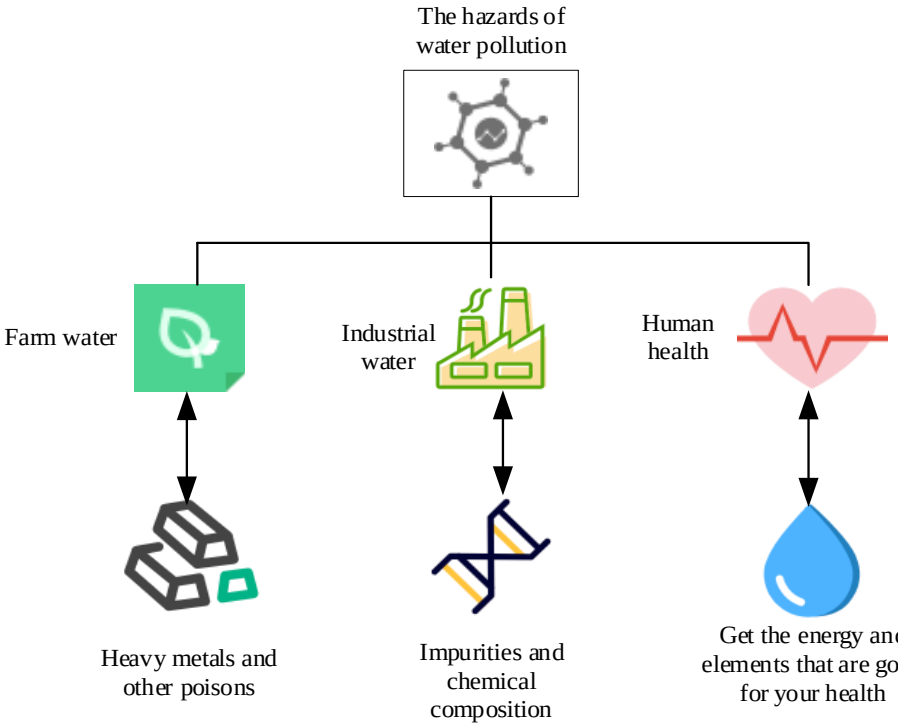


Figure 1. Hazards of water pollution

2.2.Composition of Influencing Factors of Water Pollution

The factors affecting water pollution mainly include the following contents, as shown in Figure 2.

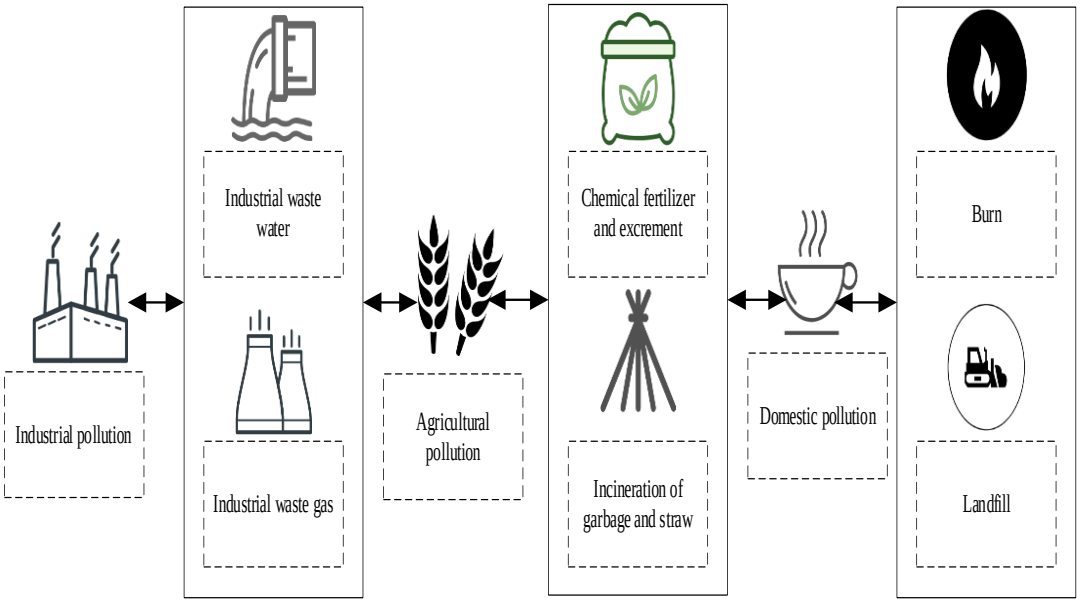


Figure 2. Factors affecting water pollution

Industrial pollution: economic development and industrial development complement each other. At this stage, a large number of industrial enterprises have emerged, which has led to a sharp increase in wastewater discharge, making water quality monitoring and treatment more difficult. Especially in the traditional industrial production mode, many enterprises pay little attention to the environment, and the sewage treatment is not in place, resulting in serious water pollution and even groundwater pollution. At this stage, the groundwater in some areas has been polluted, and industry has a great impact on the water environment. At the same time, the absorption capacity of nature to the environment is also limited. In the process of industrialization, the organic waste gas released for a long time has exceeded the natural cycle, and these pollutants gradually accumulate over time, which not only brings serious damage to the human water environment, but also affects the social and economic development [12-13].

Agricultural pollution: For a long time, fertilizer and sewage are often used in large quantities in rural areas. Although fertilizer and manure would increase soil fertility with the inflow of rain, they also lead to the breeding of bacteria and affect the health of the water environment. With the continuous deterioration of water quality in rural areas, the normal and safe water use of rural residents has been seriously affected [14]. In addition, there used to be the custom of burning garbage and straw in rural areas. After burning, a large amount of harmful substances would be produced. Rainwater mixed with harmful substances would cause certain pollution to the surrounding water sources. Therefore, the rapid development of agriculture is also an important factor in this situation.

Domestic pollution: people will produce a large amount of garbage and waste water in their daily life. If these garbage and waste water are not effectively treated, it would aggravate environmental pollution. At present, the disposal methods of domestic waste are mostly landfill and dry and wet methods. For some solid wastes, incineration is still required. The treatment of urban sewage is mainly carried out by professional sewage treatment plants. Incineration, landfill and other waste disposal methods still have a high degree of pollution to the ecological environment.

3. Risk Assessment in WP Prevention and Control Environment

3.1. Risk Elements in WP Prevention and Control Environment

This paper put forward risk factors in WP prevention and control environment, as shown in Figure 3.

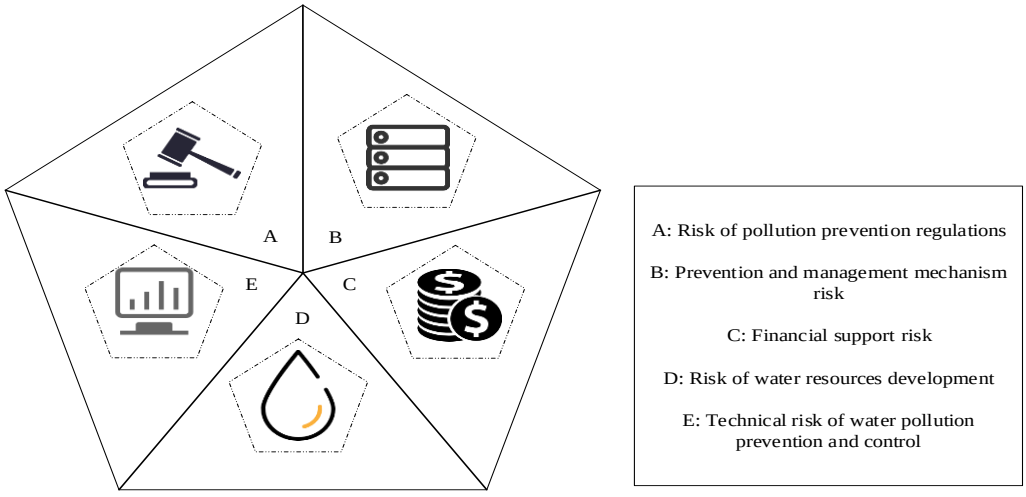


Figure 3. Risk elements in WP prevention and control environment

Pollution prevention regulation risk: although the relevant departments have formulated a series of regulations aimed at controlling WP. However, the current relevant laws and regulations are not sound enough, which restricts the implementation of the whole WP governance work. Due to the lack of corresponding laws and regulations, WP governance work is under great pressure, which also restricts the level of WP governance, making WP prevention and control have certain risks.

Risk of prevention and control management mechanism: At present, due to the restriction of WP prevention and control and the frequent separation of functions in the development and use of water resources, there are certain risks in the prevention and control of WP. Due to the lack of a sound governance mechanism, the relevant departments cannot effectively control the water quality, nor can they accurately grasp the prevention and control requirements of the development of the times, which greatly restricts the efficiency of WP governance. In addition, because rivers and waters are generally very wide, it is common for the same river to travel between different regions. In this case, it is often difficult to clearly define the scope of responsibility for cross-provincial rivers, which affects the timeliness and effectiveness of WP prevention [15].

Financial support risk: While managing WP, a large amount of funds must be invested to attract talents and technology. However, in the current WP governance work, the funds, talents and technology invested by the government are scarce, leading to the backwardness of WP governance level.

Water resources development risk: The source of prevention and control of WP should start with the development and utilization of water resources, but in this regard, the relevant departments have not paid enough attention to the utilization of water resources, that is, taking the path of pollution while treatment. Such uncoordinated development has led to the occurrence of prevention and control risk of WP.

WP prevention and control technology risk: At present, the information awareness and level of prevention and control personnel are still not high enough, and the lack of information technology application in WP prevention and control work restricts the efficient use of WP control and control information resources. In addition, the technical level of WP prevention and control work is not high enough, which affects the efficiency of WP prevention and control work. Under the background of WP prevention and control management mechanism, the insufficient level of WP prevention and control measures led to WP prevention and control risk.

3.2. Evaluation of Prevention and Control Risk Factors Based on Fuzzy Bayesian Network

By taking the above five risk factors as risk assessment indicators, negligible risk, acceptable risk and unacceptable risk are set respectively. The risk factors are transformed into nodes of fuzzy Bayesian network, and the causal relationship between the factors is transformed into a directed boundary. Based on Bayesian network, the prior probability and conditional probability distribution of each node in Bayesian network are calculated. Using the method of fuzzy sets, prior knowledge and the assistance of domain experts, the prior probability of evidence nodes and the correlation distribution between response nodes are obtained.

The natural language variables are transformed into triangular fuzzy probabilities, and then the risk level of each node is evaluated by multiple experts, which leads to Formula (1):

$$I_{pq}^{c} = \left(x_{pq}^{c}, y_{pq}^{c}, z_{pq}^{c}\right) \tag{1}$$

Among them, c refers to expert sequence.

In order to obtain a reasonable fuzzy probability, the arithmetic mean value of the evaluation results of all experts is calculated, and the probability of a fuzzy mean value is obtained:

$$I''_{pq} = \frac{I^1_{pq} \oplus ... \oplus I^c_{pq} \oplus ... \oplus I^m_{pq}}{m} = \left(x''_{pq}, y''_{pq}, z''_{pq}\right) \tag{2}$$

Using the regional average method, the fuzzy average probability is converted into the most representative probability value:

$$I'_{pq} = \frac{x''_{pq} + ky''_{pq} + z''_{pq}}{n} \tag{3}$$

By normalizing the probability of risk degree of each node to make its probability meet 1, the prior probability and conditional probability distribution are obtained:

$$I_{pq} = \frac{I'_{pq}}{\sum_{q=0}^{c} I'_{pq}} \tag{4}$$

Bayesian network is used to obtain the risk degree probability of each node. In the case of different probability distributions, the level corresponding to the maximum probability value is the level of prevention and control risk factors.

4. Preventive Measures for Water Pollution Prevention and Control Risks

Improvement of the legal system for water pollution prevention and control: first, it is necessary to fully consider the actual needs of water pollution prevention and control, and formulate more professional and systematic water pollution control regulations. From the legal level, development and prevention should be combined to provide support for water pollution prevention and control, so as to reduce the risk of water pollution prevention and control and the probability of water pollution risk occurrence. The second is to insist on punishing individuals and enterprises that pollute water bodies in accordance with the law, and continuously improve the level of water pollution control in practice, so as to achieve effective protection of the water environment.

The need to further improve the water pollution control mechanism: governments at all levels should strengthen cooperation to actively build a sound water pollution control and management system, and effectively prevent and treat water pollution, so as to ensure that people would not have any impact on the water ecological environment while using water. At the same time, water pollution control should be combined with water environment monitoring and water resources development. When continuing to develop and use water resources, it is necessary to firmly establish the concept of ecological protection and prevent the destruction of water by various polluting substances.

Attention to the overall quality of relevant departments: all relevant departments should continuously improve the professional level of water pollution control. Through special training and improvement of incentive and reward system, the professional quality and professional ability of employees in relevant departments can be fully developed. Only in this way can the effectiveness of water pollution control be improved in an all-round way.

Use information technology to improve efficiency: relevant departments should continuously improve their information awareness, reasonably and effectively apply information technology in WP prevention and control risk prevention, and improve information level. At the same time, it is also necessary to establish an effective and feasible WP prevention mechanism and working mode to ensure the effective use of WP prevention technology.

5. Practical Exploration on Risk Assessment of WP Prevention and Control

In this paper, the risk level of WP prevention and control in three urban areas of Z City was evaluated to determine the level of WP prevention and control risk in Z City. These three urban areas were called D District, X District and Q District respectively. The prevention and control risk elements were set as pollution prevention and control regulation risk, prevention and control management mechanism risk, financial support risk, water resources development risk and WP prevention and control means risk, and the three risk evaluation levels of negligible risk, acceptable risk and unacceptable risk are set. Less than 33.3 was a negligible risk, and more than or equal to 33.3 and less than or equal to 66.6 was an acceptable risk; greater than 66.6 was unacceptable risk.

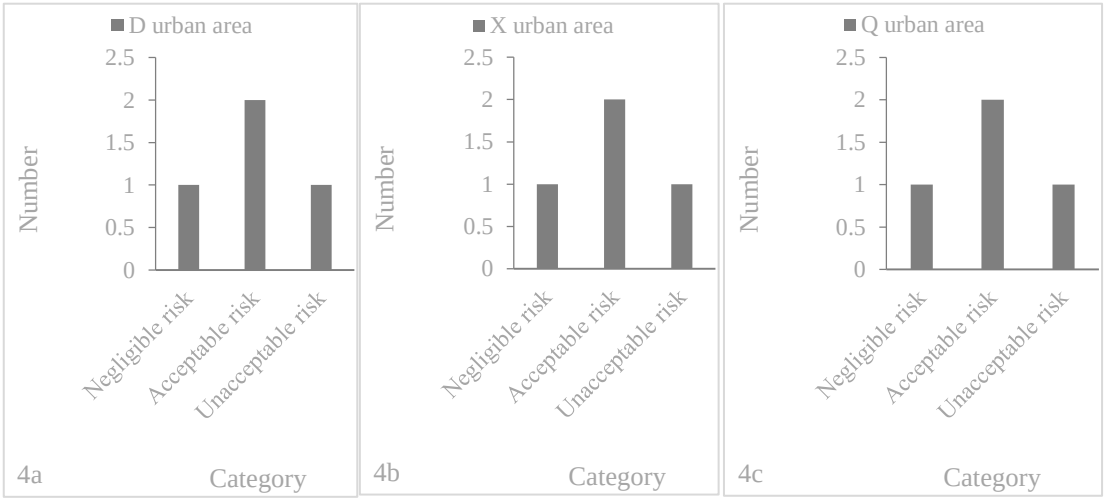
The risk of water pollution prevention and control in three urban areas was investigated, and the value range of prevention and control risk index was 1-100. The results are shown in Table 1.

Table 1. Risk of water pollution prevention and control

	D urban area	X urban area	Q urban area
Risk of pollution prevention regulations	63.6	64.5	59.3
Prevention and management mechanism risk	52.1	59.6	58.4
Financial support risk	32.7	36.9	41.7
Risk of water resources development	41.8	49.5	46.2
Technical risk of water pollution prevention and control	39.4	47.1	40.9

As shown in Table 1, on the whole, there was no significant difference in the five WP prevention and control risk indexes among District D, X and Q, but there was a certain gap in the different WP prevention and control risk indexes among the same urban area. From the perspective of averaging, if five WP prevention and control risk indicators, such as pollution prevention and control regulation risk, prevention and control management mechanism risk, represent the level of WP prevention and control risk in the urban area, then the average WP prevention and control risk index in Zone D was 45.9, which was acceptable risk level. Similarly, the average value of WP prevention and control risk index in Zone X and Q was 51.5 and 49.3 respectively, which also belonged to the acceptable risk level.

The fuzzy Bayesian network was used to calculate the WP prevention and control risk levels of three urban areas, where 2 represents belonging to a certain prevention and control risk level and 1 represents not belonging to a certain prevention and control risk level, as shown in Figure 4.



4a. D Urban WP prevention and control risk level

4b. WP prevention and control risk level in urban X

4c. Q Urban WP prevention and control risk level

Figure 4. WP prevention and control risk level in three urban areas

As shown in Figure 4, it can be seen from Figure 4a that the level of WP prevention and control risk in Zone D was acceptable. Similarly, it can be seen from Figure 4b and Figure 4c that the WP prevention and control risk level of Zone X and Q also belonged to the acceptable risk level.

6. Conclusion

Water is an indispensable substance for human survival and socio-economic development. In the further prevention and control of water ecological environment pollution, it is necessary to continue to increase its supervision and effectively put an end to the phenomenon of indiscriminate discharge in life and production. By implementing the relevant punishment and reward system, it can urge the whole society to actively participate in the cause of environmental protection. At the same time, to improve the level of water environment management, it is necessary to strengthen the research and application of relevant prevention and control risk evaluation, and realize the early warning of the risk of water ecological environment, so as to achieve the purpose of preventing the risk of water environment.

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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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