Scholar Publishing Group
Water Pollution Prevention and Control Project
https://doi.org/10.38007/WPPCP.2022.030103
ISSN 2790-2730 Vol. 3, Issue 1: 22-31

Water Pollution Prevention and Control System Based on Cluster Analysis

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Keywords: Water Pollution, Prevention and Control System, Fusion Cluster Analysis, Pollution Sources

Abstract: At present, many developing areas will have low utilization rate of water resources and serious groundwater pollution (water pollution, WP), which makes the groundwater environment situation increasingly serious. In order to curb the trend of ground WP and improve the quality of groundwater environment, it is urgent to formulate a ground WP prevention and control plan. Many researchers have provided new ideas for the application research of WP prevention and control system. This paper is based on this as the research direction and research basis. This paper analyzes the significance of WP prevention and summarizes the application of WP prevention and control system and cluster analysis in WP prevention and control. This paper then establishes an algorithm model, and proposes relevant algorithms to provide theoretical basis for the application research of WP prevention and control system based on cluster analysis. At the end of the paper, the simulation experiment is carried out, and the experiment is summarized and discussed. According to the establishment of WP prevention and control systems in A and B, the growth rate of sewage from agricultural pollution sources from 2018 to 2022 is 29.5%. It can be inferred from the amount of sewage from agricultural pollution sources that this area is an industrial developed area. At the same time, with the in-depth study of fusion cluster analysis, the application research of WP control system is also facing new opportunities and challenges.

1. Introduction

WP makes water resources scarce in many areas, which not only directly threatens people's drinking water safety, but also brings huge economic losses to industry, agriculture and food. One of the important reasons is the low treatment rate of urban sewage. A large amount of sewage is

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discharged to the outside without treatment, resulting in WP and water shortage. In addition, the rapid development of urbanization and industrialization has caused a large amount of urban wastewater and WP. At present, the slow development of urban sewage treatment has become one of the main reasons that affect the goal of WP control, and also the bottleneck that restricts the sustainable development of urban society and economy.

Research on WP prevention and control system. Li Z believed whether the river chief system can effectively alleviate NPS (NS-pointSource) pollution is crucial for achieving green development [1]. Sheng Jichuan studied that the WP control of the South-to-North Water Transfer Project is carried out from the perspective of publicity competition to provide a special perspective of water supply politics and WP control methods [2]. Ahmed Shahid's research shows that citizen participation in awareness-raising campaigns and strict enforcement of environmental laws by relevant institutions are appropriate solutions to control environmental degradation. It is recommended to have an appropriate waste treatment system, and waste should be treated before entering rivers and water bodies [3]. Shukla Bishnu Kant studied the quality parameters of groundwater around many areas and determined the degree of pollution of such groundwater. To determine the different physical and chemical characteristics of groundwater in the area, and estimate the impact of these parameters on the overall environment, especially human health [4]. Chen Sophia Shuang investigated the role of anthropogenic pollution in the water quality deterioration of rivers around the world, especially as water quality monitoring in urban areas is still severely limited by limited testing facilities and capacity[5]. Belokopytov V N modeled the transport process of pollutants and impurities flowing from different sewers according to the diagnostic calculation of the water cycle in Sevastopol Bay [6]. Rehman Shafique Ur believes that although the impact of various types of intangible resources on ecological sustainability and sustainable performance has been extensively studied in the literature, environmental strategies and organizational capabilities have been used to determine the ecological sustainability and sustainable performance of construction organizations [7]. The above studies have achieved good results, but with the continuous updating of technology, there are still some problems.

The application of cluster analysis in WP control. Liu Yi's research results show that the combination of the improved GRD (Geophysics Research Director) model and EKC (Environmental Kuznets Curve) provides a new method for comprehensively investigating the relationship between WP and economic growth from a qualitative and quantitative perspective [8]. Wu Jianhua Check the groundwater quality defined by different water quality parameters. The aim was to understand the relationship between different groundwater quality parameters and to trace the source and influencing factors of subsurface WP using statistical and multivariate techniques[9]. Nguyen Hiep Duc adopted statistical and modeling methods to study the water quality status and environmental properties of the waterways in the Thanai River basin in Saigon, as well as the impact of point sources and diffuse pollution sources [10]. Li Peiyue proposed study aims to highlight its water management and support in fighting floods and water shortages and improving inland areas [11]. Dai Yingjie researched the overuse and undisturbed emissions are also considered to cause severe groundwater pollution. Try to summarize the latest knowledge on its nature, source, pollution status, effect on the environmental toxicity of water, etc. [12]. The above research shows that the application of cluster analysis has a positive effect, but there are still some problems.

This paper studies the application research of WP prevention and control system based on fusion cluster analysis. First, it analyzes the inducements and prevention countermeasures of WP, then gives its relevant content, designs the WP prevention and control system, and provides theoretical basis for the experiment through relevant algorithms. Finally, it compares and analyzes the WP prevention and control systems of the two places under the cluster analysis method, providing reference significance for such research.

2. Inducement and Prevention Measures of WP

(1) Inducement of WP

WP mainly comes from WP sources. It generally refers to the facilities that discharge pollutants in the water body or cause adverse effects on the water body [13]. According to the causes, it can be divided into two types: natural sources and man-made sources. According to the type of human behavior, human pollution sources can be divided into industrial pollution sources, agricultural pollution sources, domestic pollution sources and traffic pollution sources, as shown in Figure 1;

WP is caused by human factors. The main reason for human production is industry. The composition of pollutants in industrial sewage is complex, which is difficult to purify and effectively control in water [14].

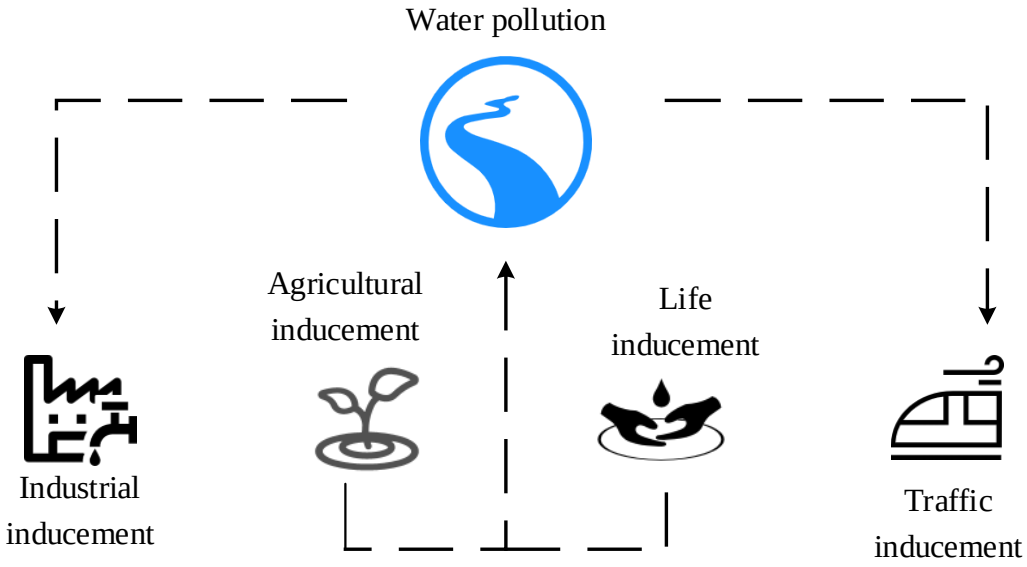

Figure 1. The causes of water pollution

1) Industrial inducement

Industrial wastewater is an important factor affecting the quality of water environment. Due to different production enterprises, the content of pollutants in wastewater varies greatly. Even the same enterprise has different types of pollutants due to different treatment methods. In addition to direct discharge of wastewater into the water body would cause certain pollution to the environment, it would also produce solid waste, waste gas, etc.

2) Agricultural inducement

Due to the development of agriculture, the surface of the marsh becomes loose. When the soil form is not stable, a large amount of rainfall flows into the river, making it more uneven; In addition, the use of pesticides and fertilizers is also increasing, but the use of pesticides and fertilizers is small, most of which are adsorbed in the soil and floating in the air.

3) Life inducement

The pollution sources of cities are urban population density, domestic sewage, garbage, waste gas, etc. The main pollution source of the city is domestic sewage, including sewage from kitchens, washrooms, toilets and other places.

4) Traffic inducement

Vehicles and equipment may pollute the water environment. It mainly includes transportation tools, equipment washing water, ballast water, etc. The characteristics of pollutants are closely related to the characteristics of toxic and harmful substances they carry. Sudden pollution in traffic

accidents is the main source of WP in recent years.

(2) Prevention and control measures of WP

This paper summarizes several aspects of WP prevention and control measures, as shown in Figure 2:

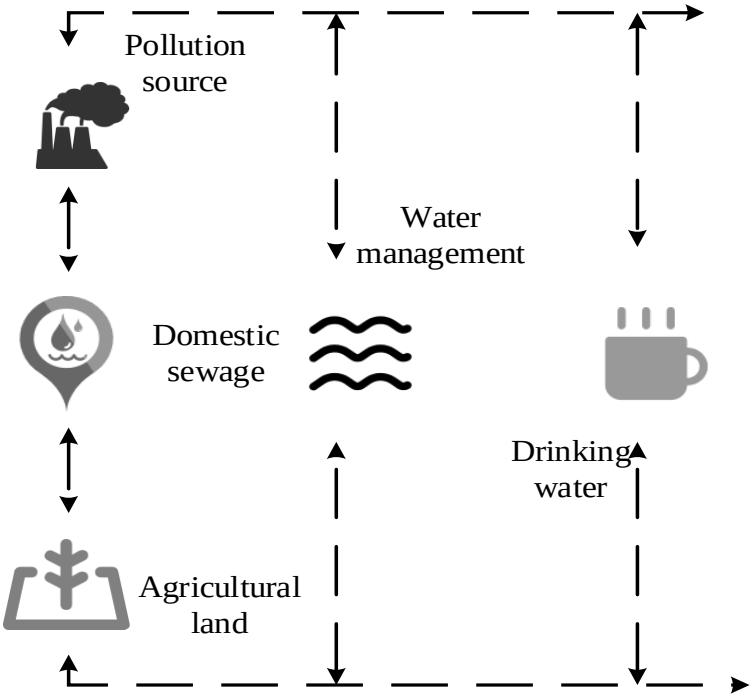

Figure 2. Prevention and control countermeasures of water pollution

WP Prevention and Control is a comprehensive system project that includes policy, management technology, market regulation, and collaboration between the entire population. Prevention and control of WP should be closely linked to economic and social development and should be coordinated for comprehensive treatment[15].

First, people should strengthen the control of point source pollution and strictly discharge pollutants. Industrial sewage and domestic garbage shall be strictly controlled to reach the standard. Through the method of reward and punishment, enterprises can play a better role in controlling environmental pollution.

Second, for the treatment of urban domestic sewage, comprehensive measures should be taken to implement quota management and gradually increase the water price to realize water saving and pollution reduction by economic leverage. It is necessary to establish a reasonable pollution charge standard to realize industrialization, and give policy and financial support to a certain extent. Gradually realize the marketization and industrialization of wastewater treatment, and reduce the cost of wastewater treatment in the competition to achieve a good cycle.

Third, people must control the inaccurate pollution of agricultural land from a macro perspective, change agricultural methods, adjust agricultural industrial structure, develop green agriculture and use chemical fertilizers and pesticides rationally, increase the use of organic fertilizers and minimize the sources of inaccuracies.

Fourth, people should strengthen the management and reasonable regulation of rivers, lakes, reservoirs and other waters to improve the carrying capacity of water environment. Lake water management is different from river management, and it is necessary to strengthen management and strengthen engineering construction. Take effective measures to control domestic sewage,

agricultural non-point source and endogenous pollution. Formulate a scientific and reasonable water distribution and river dredging scheme to ensure that the river does not decay and improve the self-cleaning of the water body [16].

Fifth, people should strengthen the management of drinking water to ensure the safety of drinking water. At present, the measures to solve drinking WP mainly include: controlling pollution sources, increasing the treatment rate of domestic and industrial wastewater, promoting water-saving technology, increasing the recycling of industrial water, and recycling urban sewage. Based on advanced technology and local conditions, the theory, method and method of ecological restoration technology are discussed and combined with physics and chemistry to accelerate the speed of ecological restoration.

(3) Design of WP prevention and control system

The design content of the WP prevention and control system is summarized in the following figure 3:

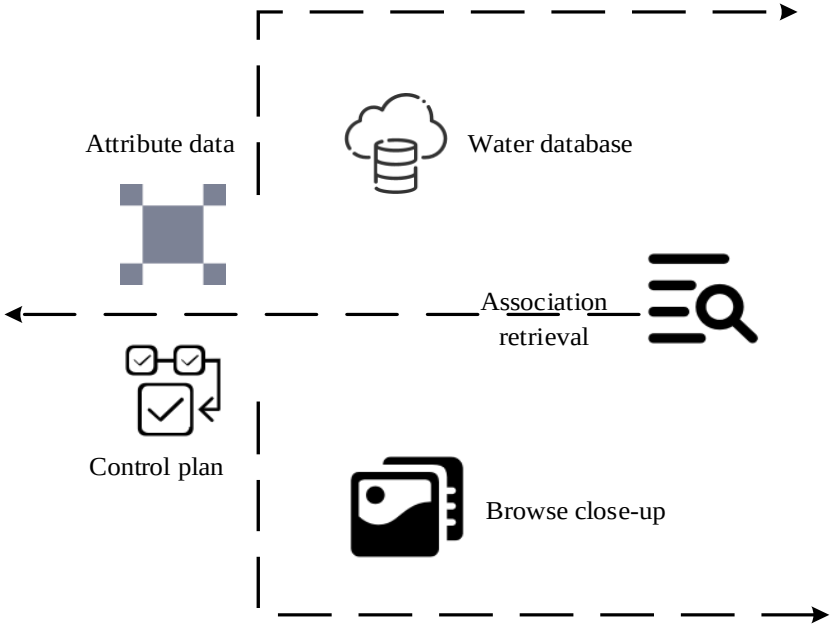

Figure 3. Design of the water pollution prevention and control system

1) Water database

Because the data was input into the system at the early stage of development and a groundwater database was built on this basis. Therefore, the main function of this module is to import, summarize, backup and restore the attribute database established in the previous stage.

2) Attribute data

Its main function is to extract relevant attribute data from the database by entering specific query conditions. Its goal is to provide data basis for analysis and evaluation. Its implementation method is to provide a query condition in the query design tool to provide users with search results.

3) Control plan

According to the assessment methods and indicators specified in the WP control plan, assign pollution sources and organize monitoring points and projects to prevent and control pollution in specific areas through thematic maps in the form of visual and dynamic reflection, as well as the specific requirements of the WP plan, as the basis for formulating the underground WP prevention plan and organizing prevention and control activities [17].

4) Browse close-up

The data is stored in the form of graphic data and database, and the attribute data and image data are displayed in different windows at the same time.

5) Association retrieval

The region is established in various ways to realize the associated retrieval and non-associated retrieval inside and outside the region. Attribute-based conditional retrieval is to input query conditions into statements to achieve the purpose of query. Whether it is feature extraction based on space or conditional search based on attributes, the results are presented in the form of continuous rolling.

3. Fusion Clustering Analysis Algorithm and WP Prevention System

(1) Analysis of fusion cluster analysis

When solving a large number of practical problems, it is necessary to cluster the data. For example, the system would monitor the water flow and pollution level of the water source, which not only has a large number, but also contains the attributes of numbers and classes. Fusion clustering is a development direction in recent years. Its basic idea is to cluster the original data with several separate clusters, and then combine them to get the clustering results of the original data.

This method is superior to the single clustering method in robustness, stability and applicability. Therefore, the current research on cluster fusion mainly focuses on the following aspects: how to effectively generate cluster members; How to construct consistent functions to generate effective clustering and fusion algorithms.

(2) Application of fusion cluster analysis algorithm and WP prevention

The data type and normalization in clustering should be used to cluster the data, and the correct data type should be determined first. At present, there are two common data formats: data matrix and dissimilarity matrix.

Assume that there are n samples in a clustering problem: $x_p(p=1,2,...,n)$, each sample has m attribute factors, the l attribute factor of the p sample point is represented by x_{pl}, and n samples can be arranged as the data matrix of $n \times m$ dimension:

$$Z = \begin{bmatrix} z_{11}, z_{12} \ldots z_{1m} \\ z_{21}, z_{22} \ldots z_{2m} \\ \ldots \\ z_{n1}, z_{n2} \ldots z_{nm} \end{bmatrix} \tag{1}$$

In the WP monitoring system, such data matrix is adopted for the original sampling data. Each monitoring point is a sampling monitoring indicator, that is, attribute factor.

Dissimilarity Matrix

If there are n sampling problems, the dissimilarity matrix stores the approximation of n sampling pairs to form a dimensional matrix:

$$\begin{bmatrix} 0 \\ b(2,1),0 \\ b(3,1), b(3,2),0 \\ b(n,1), b(n,2), b(n,3),0 \end{bmatrix} \tag{2}$$

Here, $b(p,l)$ quantitatively expresses the dissimilarity of sample p and sample l; Generally, this value is not negative. If the sample p is closer to l, its value is closer to 0; If the difference between the two samples is greater, the value would be greater.

In order to ensure that all attribute factors in the analysis are in the same position, standardization must be carried out. On this basis, the attribute factor values of all samples are converted to [0,1] and normalized. The data normalization in this paper is as follows:

The p-th sample data is expressed in vector form:

$$x_p = (x_{p1}, x_{p2}, ..., x_{pm})^T \tag{3}$$

Transform each attribute value on each sample so that they have the same base point, and record the average value of the nth attribute as:

$$\bar{x}_l = \frac{1}{n}\sum_{p=1}^{n} x_{pl} \tag{4}$$

l=1,2, m

Calculate the standard deviation of the first attribute:

$$S_l = \sqrt{\frac{1}{n-1}\sum_{p=1}^{n}(x_{ipl}\bar{x}_l)^2} \tag{5}$$

Use the formula to normalize the n sample data of the first attribute in turn:

$$x'^{n}_{pl} = \frac{x_{pl} - \bar{x}_l}{S_l} \tag{6}$$

4. WP Prevention System in A and B

Comprehensive treatment is to take a variety of methods to comprehensively control WP from the overall perspective. The relative shortage of water resources in many regions is mainly divided into two categories: resource-based water shortage and water quality water shortage. For a long time, the purification of sewage outlets based on point source control has not been able to solve the problem of WP. Only through comprehensive treatment from the perspective of the source, can WP be controlled and solved from the source. Table 1 shows the four types of WP emissions in a region from 2018 to 2022:

Table 1. Four types of WP discharge in a certain area from 2018 to 2022

	Agricultural pollution sources (100 million tons)	Industrial pollution sources (100 million tons)	Domestic pollution sources (100 million tons)	Traffic pollution sources (100 million tons)
2018	241	271	94	57
2019	263	291	106	62
2020	271	306	124	73
2021	301	336	139	91
2022	324	351	157	103

From Table 1, it can be seen that the amount of sewage from agricultural pollution sources, industrial pollution sources, domestic pollution sources and traffic pollution sources has increased

year by year since 2018. The growth rate of sewage from agricultural pollution sources from 2018 to 2022 is 34.4%; the growth rate of sewage from industrial pollution sources from 2018 to 2022 is 29.5%; the growth rate of domestic pollution sources from 2018 to 2022 is 67%; The growth rate of sewage from traffic pollution sources from 2018 to 2022 is 80.7%. It can be inferred from the amount of sewage from industrial pollution sources that this area is an industrial developed area.

Based on the above research on the application of WP prevention and control system, this paper would establish WP prevention and control systems in A and B to solve the local WP problems. Region A uses the traditional method to establish the system and Region B uses the fusion cluster analysis to establish the WP prevention and control system. The specific results are shown in Figure 4. Through comparative analysis of industrial pollution sources, agricultural pollution sources, domestic pollution sources and traffic pollution sources, the results of the experiment are summarized and discussed:

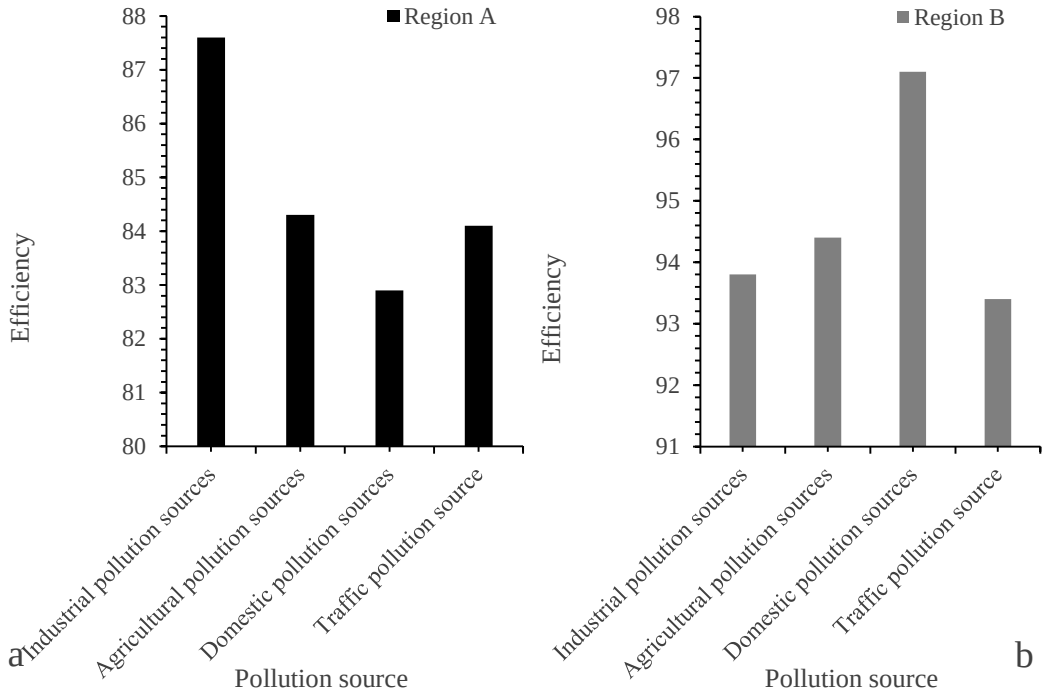

Figure 4a. Control efficiency in region A

Figure 4b. Control efficiency in area B

Figure 4. Prevention and control efficiency in both regions

Figure 4a shows the prevention and control effectiveness of Region A on the above four pollution sources, and Figure 4b shows the prevention and control effectiveness of Region B on the above four pollution sources. It can be seen from Figure 4 that among the four pollution sources causing the occurrence of area A, the effective rate after the establishment of WP prevention system is below 90%; The effective rate after the establishment of WP prevention system in Region B is more than 90%. Among them, the effective rate of prevention and control of industrial pollution sources in region A is 87.6%, which is 6.2% higher than that in region B; The effective rate of prevention and control of agricultural pollution sources in region A is 84.3%, which is 10.1% higher than that in region B; The effective rate of prevention and control of domestic pollution sources in Region A is 82.9%, which is 14.2% higher than that in Region B; The effective rate of prevention and control of traffic pollution sources in Region A is 84.1%, which is 9.3% higher than that in

Region B.

To sum up, this paper studies the application of WP control system based on fusion cluster analysis. On this basis, it is believed that comprehensive treatment of WP should be carried out from the perspective of region and water system, and WP should be controlled from the source to solve the problem of water shortage.

5. Conclusion

With the rapid development of economy, the pollution of water resources is aggravated. The prevention and control of WP is to control the physical properties of the water body. The utilization of water resources has adverse effects on human health and ecological environment, resulting in the deterioration of water quality. At present, with the fusion cluster analysis, the application research of WP prevention and control system has achieved many successful cases and concept validation, and the water conservancy system of the whole region has been optimized through relevant technologies.

Funding

This article is not supported by any foundation.

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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