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Research on Pollution Control and Remediation of the Sangu Spring Area Based on the Evolution of the Water Environment

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Abstract: This paper mainly takes the Renzhuang subsystem and Changhe subsystem of the Sanguquan watershed as the research object to analyze the natural environmental conditions of the area, to carry out the analysis of water chemistry types and groundwater characteristics, and to analyze the pollution characteristics of surface water and groundwater in the watershed, and finally finds that the pollution sources in Sanguquan watershed mainly include industrial pollution (coal mine pit sewage, fertilizer factory, and power plant wastewater), agricultural pollution (agricultural fertilizers and pesticides), and domestic pollution (domestic pollution, domestic waste), so according to the different sources of pollution to propose targeted water pollution control and remediation programs, aimed at achieving sustainable use of water resources. This study provides a scientific basis for water pollution control and remediation in the Sanguquan area. It gives some references to the selection of measures for different pollution sources and pollution pathways.

1. Introduction

With China's rapid social and economic development, accelerating urbanization, and increasing industrialization, a series of worrying problems have emerged in society, such as structural shortages of water resources, wastage of water resources, irrational water resources development and utilization, and increasingly severe water pollution, which have become essential factors restricting the sustainable development of China's economy and society and affecting people's health. Therefore, how to scientifically, reasonably, and effectively develop and utilize water resources, control and manage water pollution, and realize the sustainable use of water resources has become the focus of current and future work[1]. As the primary water supply source of Jincheng City, the Sanguquan Spring area has a stable quantity and good quality of karst groundwater, which plays a vital role in the economic and social development of Jincheng City. However, due to the discharge of industrial wastewater from coal mines, the chemical industry, and other human activities, the flow rate of Karst Springs has continued to decline, the water quality has suffered from severe pollution, and the water environment of Karst Springs has significantly changed.

2. Research Methodology

2.1 Basic information about the study area

Sanguquan is located in the Dan River Valley in the southern part of Zezhou County, Jincheng City, Shanxi Province, on the border with Henan Province. North and Changzhi City, adjacent to the west and Yangcheng County, east and south and Jiaozuo City, Henan Province, bordering the geographic location between 111 ° 55 ′ ~ 113 ° 36 ′ longitude, latitude 35 ° 12 ′ ~ 36 ° 04 ′ between the springs, including mainly in the urban areas of Jincheng City, Zezhou County, GaoPing City, and most of Lingchuan County, a total area of about 257km ². The spring to the upper reaches along the Dan River and Guobi Spring, Baiyang Spring, Taipei Spring, etc., the discharge zone average flow rate of 7.2 ㎥/s is one of the vital karst springs in Shanxi Province, the area of the urban population concentration, industrial and agricultural production is well developed, is the city of Jincheng, politics, economy, culture, transportation center. As an essential karst spring in Shanxi Province, the water quality has been deteriorating in recent years under the influence of natural and anthropogenic factors. In this paper, we take the Sangu Spring Spring area as a research object and study its water environment pollution characteristics in depth, hoping that it can play a role in controlling and repairing the water pollution in the area.

2.2 Data acquisition

This paper collects the natural and anthropogenic environmental conditions of Sangu Springs, which include meteorological and hydrological conditions; topographic and geomorphological conditions; stratigraphic and lithological conditions, geological and tectonic conditions, and hydrogeological conditions of karst water in the springs; and anthropogenic environmental conditions, which include the types of pollutant sources and their distribution characteristics, pollutant characteristics, and river outfalls and their characteristics. Relevant data were collected and analyzed.

2.3 Introduction to the Methodology

First of all, the water environment type and its characteristic analysis, the use of Excel tables were calculated groundwater quality monitoring points of mineralization and various ions of the milligram equivalent percentage, and the use of Kurysov formula, according to which Shukarev classification, and make the water chemistry type map, the main river in the area of the Sanguquan Dan River, and its main tributaries are the Chang River, Baishui River, Bakong River and Beishidian River. Surface water environment quality evaluation includes river water quality Renzhuang Reservoir water quality, evaluation factors using the "surface water environment quality standards" (GB3838-2002) evaluation, with a single factor "on the high rather than low, from the excellent not from the poor" and comprehensive indicator evaluation "on the low rather than high, from the poor not from the good" principle. The environmental quality of surface water is evaluated based on the principle that individual factors are "higher rather than lower, better rather than worse," and comprehensive indicators are evaluated as "lower rather than higher, worse rather than better."

3. Analytical process

3.1 Characterisation of pollution in the water environment

In this paper, we mainly analyze the Renzhuang and Changhe subsystems. Combined with the map of groundwater chemistry types in the spring area, we can get the following judgment: the

groundwater chemistry types in the area of the Renzhuang subsystem are dominated by the 9-A and 2-A, followed by 8-A, and the corresponding chemistry types are respectively$HCO_3 + SO_4 - Ca + Mg$ Type, $HCO_3 - Ca + Mg$ type.$HCO_3 + SO_4 - Ca$ type. The groundwater chemistry types in the Changhe subsystem area are dominated by 9-A, followed by 8-A, and the corresponding chemistry types are $HCO_3 + SO_4 - Ca + Mg$ type, respectively. $HCO_3 + SO_4^{2-} - Ca$ Type, Renzhuang subsystem The catchment area of this subsystem extends from Lingchuan to the Dan River central stream basin zone along Renzhuang, including part of the East Dan River basin. Due to the stratigraphy tilted to the west or northwest, the atmospheric precipitation infiltrated in the eastern exposed and semi-exposed soluble rock area carries on the downward seepage in the O2 greywacke and collects to the west to form a strong zone with a near-north-south direction along a line from Renzhuang Reservoir to Guobiquan. The Renzhuang subsystem, in the beginning, went through the dissolution-filtration action, dissolving and filtering the grey rocks, and the groundwater dissolved a large amount of HCO_3^- ,SO_4^{2-} ,Ca^{2+} ,Mg^{2+}. There are two different processes of water chemistry evolution in this subsystem. One process is along the measuring points SJ5, S36, S33, and S58, which are karst water, along the direction of water flow. As the runoff time becomes longer, the mineralization of the groundwater gradually increases, with the$HCO_3 - Ca + Mg$ type of water dominating the HCO3-Ca+Mg type of water. Another process is SJ6, SJ7, S26, which belongs to pore water, affected by the fertilizer factory, coal mine, and other resources; SO_4^{2-}, Ca^{2+}, andMg^{2+} Ion content increases, forming$HCO_3 + SO_4 - Ca + Mg$ type water with high mineralization. With the flow of water, the tributaries converge, the concentration is diluted, and the mineralization of groundwater decreases. After Beiyi, the groundwater carries on the solid runoff zone of Renzhuang Reservoir-Shuidong-Ministry of Wall Spring, the runoff and sparse alternating blocks, the dissolution and filtration effect is strengthened, the easily soluble salt ionSO_4^{2-} content decreases, insoluble salt ions Ca^{2+} and HCO_3^- become the primary ions, the emergence of $HCO_3 - Ca + Mg$ The mineralization of the type water decreases gradually. The Changhe subsystem is in the basin of Xuhe, a tributary of Danhe, west of the Jinyu Great Fracture, and its recharge zone is mainly the O2 greywacke exposed in the western disc of the fracture zone, which receives infiltration of atmospheric precipitation and recharge from the seepage of Xuhe. The boundary between this subsystem and the Gaoping Jincheng subsystem has no obvious surface watershed at the surface, but there exists a movable subsurface watershed. At its inception, the subsystem underwent solifluction, which solifluctuates greywacke, and the groundwater dissolved a large amount of $HCO_3^-, SO42-, Ca2+, and\ Mg^{2+}$. The overall water chemistry of the region is of the$HCO_3 + SO_4 - Ca + Mg$ type, while in the part close to the town, polluted by factory wastewater, domestic sewage, etc., the more prominent feature is that the CL- content of monitoring point S17 is elevated, which is much higher compared to that going to the monitoring point S19. The influence of these effluents leads to the change of the water quality in the vicinity of monitoring point S17 to a$HCO_3 + SO_4 - Ca$ type[2].

The characterization of surface water pollution is analyzed as follows: this water quality evaluation of the reservoir adopts a single-factor evaluation method, combining the environmental quality standards for surface water with the water quality evaluation of Renzhuang Reservoir, and the water quality of Renzhuang Reservoir is poorer in terms of COD and fluoride concentration, and poorer during the non-nodal period compared with the flood season. The water quality in terms of total hardness and dissolved oxygen is above class II. Renzhuang Reservoir is built in the exposed and semi-exposed area of grey rock, and the lithology of the reservoir area is mesotrophic. The reservoir is built on the Dan River, which is obviously affected by its water quality, and the higher fluoride concentration of the Dan River leads to the correspondingly higher fluoride concentration in the reservoir. Jincheng City's industrial structure is coal, electricity, chemical metallurgy, machinery industry, etc.; the primary polluting industries in the rivers of Jincheng City are the chemical industry

and coal industry, the leading industrial polluting enterprises are distributed in the Dan River Basin in Gaoping City, Jincheng City, Zezhou County, a large number of mining and industrial enterprises and the city of living wastewater discharged into the river, resulting in 60% of the Dan River section of the river is seriously contaminated, which led to the pollution of the reservoir. The increase in population, the rapid development of the city scale, the urbanization rate, and the improvement of people's living standards make the urban life of water consumption an increasing trend, and the life of the wastewater has also increased[3]. With the continuous progress of science and technology, the type and quantity of synthetic chemical products used in people's lives are increasing, making the type and quantity of pollutants in life also show a rising trend.

A large number of applied fertilizers and pesticides, in addition to being absorbed by crops, decompose most of the residue in the soil and water, after which it will enter the water body with the surface runoff, resulting in pollution. Atmospheric precipitation is also the primary source of recharge of the reservoir; the PH value of atmospheric precipitation is small, and the reservoir receives more atmospheric precipitation recharge during the flood season, thus making the PH value of the water in the migrating reservoir smaller than its PH value during the flood season. The higher concentration of ammonia and nitrogen in the atmospheric precipitation has an impact on the concentration of ammonia and nitrogen in the reservoir. The water quality of the river was also evaluated using the single-factor evaluation method. The section of Dan River from Xiaozhaozhuang to Hexi River and its tributary Bagong River were seriously polluted, and the water quality was inferior to the V class. Ammonia nitrogen, chemical oxygen demand, biochemical oxygen demand, and fluoride concentrations in the section from Xiaozhaozhuang to Hexi River exceeded the standard.

In contrast, ammonia nitrogen, chemical oxygen demand, biochemical oxygen demand, total hardness, and fluoride concentrations in Bagong River exceeded the standard. The primary polluting industries of rivers in Jincheng City are chemical and coal industries, and a large number of industrial and mining enterprises and urban sewage discharged into the river, causing pollution. Dan River and Bagong River suffered severe pollution due to the admission of wastewater. Living sources of pollution refers to the sewage generated by human consumption activities; urban and densely populated residential areas are the primary sources of living pollution. Domestic sewage contains organic matter, synthetic detergents, and fluoride, as well as pathogenic bacteria, viruses, and parasite eggs. This domestic sewage is discharged into rivers, which significantly deteriorates their water quality. Fertilizers and pesticides are used in large quantities, and their residuals enter water bodies with surface runoff, causing pollution[4].

The characterization of groundwater contamination is as follows: using the Nemero index method, a single factor index is first evaluated for a single component to classify the quality category to which the component belongs; the score Fi for the evaluation of a single component is determined for each of the five classes of groundwater according to the following provisions; and the comprehensive evaluation score F is calculated:

$$F = \sqrt{\frac{Fmax^2 - Fave^2}{2}} \tag{1}$$

According to the F value, the groundwater quality level is divided, and the water quality status of each point in Renzhuang subsystem i are shown in Figure 1:

The Water Quality Status of Each Point in Renzhuang Subsystem		
Excellent Water Quality	Good Water Quality	Poor Water Quality
S34	SJ5	S33
SJ2	SJ6	S35
SJ3	SJ7	S58
	S36	S52
	S21	S32
	S26	
	S53	
	S49	
Pore Water	Fissure Water	Karst Water

Figure 1: The Water Quality Status of Each Point in Renzhuang Subsystem

The table above shows that pore water quality is generally poor, as is fissure water quality, while karst water quality is generally good.

This subsystem receives atmospheric precipitation and surface water recharge from the Renzhuang Reservoir - Xiaohuiquan area. The catchment area of this subsystem extends from Lincheon to the Dan River central stream basin zone along Renzhuang, including part of the East Dan River basin. Due to the stratigraphy tilted to the west or northwest, the eastern part of the area is exposed. The atmospheric precipitation in the semi-exposed soluble rock area infiltrates and then seeps downward in the O2 greywacke and collects to the west, forming a solid zone with a nearly north-south direction along the line from Renzhuang Reservoir to Guo Biquan and the seepage of the surface water from Renzhuang Reservoir and the mainstream of the Yuehe River, which also strengthened the development of the runoff zone. The discharge of groundwater flow in this subsystem is partially discharged at Guobi Spring, and the other part crosses 01 into the E2 aquifer and is discharged at Sangu Spring[5].

Combined with the environment around the monitoring point, we found that S33, S35, S58, and S52 points are relatively close to the town, the town development of domestic and industrial wastewater discharged into the river in Renzhuang Reservoir, a small spring along the infiltration of groundwater recharge, so that the quality of groundwater deterioration of sulfate, hardness exceeds the standard, the source of contamination is industrial, domestic wastewater, the pollutants are mainly sulfate in the wastewater of the mine pit, calcium, magnesium ion S26, S53, S49 are in the strong runoff zone of Renzhuang Reservoir ShuiDong - GuoBiQuan, although there is the recharge of surface water along Renzhuang Reservoir - XiaoQuanQuan, brought in pollutants, due to the rapid alternation of runoff, pollutants are taken away or diluted faster, so the water quality is better. Point S32 is close to the town of Liyi, where the water quality is poorer, and sulfate and total hardness exceed the standard, which may be due to the discharge of Liyi Town, where the water quality is worse. This may be due to the discharge of domestic sewage in Liyi Township plus the nearby Meiling Mountain Coal Mine and Yunquan Coal Mine wastewater containing excessive content of sulfate, calcium, magnesium, and other ions seepage into the groundwater caused by continuous infiltration type.

The Chang River subsystem runs from the Sengsheng section to the Chuanji section via the Sengzhuang coal mine, resulting in a decrease in water quality to Category IV. The Chuan Di section is located in the mainstream of the Chang River, with a length of 45.2 m. The water quality category is IV during the non-flood season, representative of the whole year. However, during the flood season, due to the large volume of water, which can dilute and wash away pollutants and speed up the flow of water, the water quality of this section of the river is still Category III, which can be applied to

general industrial areas and recreational water areas where human beings do not come into direct contact with each other. This subsystem is in the Xu River basin, a tributary of the Dan River, west of the Jinyu Great Fracture, and its recharge is mainly from the O2 greywacke exposed in the western disc of the fracture zone, which receives infiltration from atmospheric precipitation and seepage recharge from the Xu River. The boundary between this subsystem and the Gaoping-Jincheng subsystem has no obvious surface watershed at the surface, but there is a movable underground watershed. Its groundwater quality monitoring points are S17 and S19. The water quality of S17 is class V, with a high concentration of sulfate and nitrate, high total hardness, and mineralization. The water quality at S19 is class IV, with a high concentration of sulfate and high total hardness. The primary sources of pollutants are raw treatment sewage and industrial wastewater discharged from GaoPing City and fertilizer applied to farmland, which seeps into the groundwater after rainfall or irrigation. The former mainly carries calcium and magnesium ions with excessive content into the groundwater through seepage, leading to the increase of total hardness and mineralization, which belongs to the continuous seepage type; the latter is mainly the nitrogen fertilizer used in farmland, which contains nitrate substances, and is dissolved into the water after rainfall or irrigation, and then seeps into the groundwater along with the water flow, which belongs to the intermittent seepage type. The primary sources of pollution in the Sangu Spring area are industrial pollution (coal mine pit sewage, fertilizer factory, and power plant wastewater), agricultural pollution (agricultural fertilizer and pesticides), and domestic pollution (domestic pollution, domestic waste).

3.2 Water pollution control and remediation design

3.2.1 Water pollution control

The water pollution control targets are mainly industrial (power plants, fertilizer plants) pollution, agricultural pollution (mainly pesticides and fertilizers), domestic pollution, etc. Its water quality seriously exceeds the standards for ammonia nitrogen, chemical oxygen consumption, biochemical oxygen demand, total hardness, and oxides. Since the surface water of this spring area is mainly used for general industrial water use areas and recreational water use areas that are not in direct contact with human beings, the degree of surface water restoration only needs to reach IV water quality standards. Its restoration project is mainly to reduce its total hardness and chemical oxygen consumption.

Water pollution control methods have total hardness control measures and methods, including ion exchange method, reaction osmosis wall, lime method, pretreatment + nanofiltration membrane method, membrane separation method

3.2.2 Water Pollution Remediation Design

Technical means: deep water extraction technology with chemical oxygen demand control measures. Both surface water and groundwater in the evaluation area are polluted to a certain extent, among which Dan River, Baishui River, Bagong River, and Beishidian River Basin, and groundwater pollution damage is more serious; Renzhuang Reservoir water total hardness, COD are in line with the standard. In this regard, respectively, the above surface rivers and groundwater are target sites for remediation, the use of appropriate remediation techniques for water pollution remediation[6].

3.2.3 Remediation of water pollution in surface rivers

The basic principles of restoration mainly include the following aspects: (1) systematic planning and comprehensive management. Starting from the overall situation, take into account the source of the river, upstream and downstream, the estuary, the principal and tributary streams, the natural

environment and social development along the coast, and other aspects. (2) Focus and gradual implementation. In the specific implementation of river restoration projects, it is necessary to highlight the key points, prioritize the rivers in order priority, and then implement them step by step according to the financial conditions. (3) Adapting to local conditions and local materials. This can assist with the environment around the river and can effectively reduce the investment and cost of price restoration. (4) Scientific testing and management. The restoration of the Dan River and its tributaries needs to involve long-term scientific testing, a timely grasp of the dynamic changes and trends in river ecology, and the development of scientific management measures to ensure the effectiveness of restoration[7].

The objective of remediation is to take the above-surface rivers and groundwater as the target sites for remediation and adopt appropriate remediation technologies to remediate the water pollution so as to restore its ecological functions and meet people's needs.

Restoration techniques include deep water extraction and river aeration and reoxygenation, which are divided into three steps: (1) mechanical mixing, (2) injection of pure oxygen, (3) injection of air.

3.2.4 Remediation of groundwater pollution

The basic principles of remediation include the following: 1. Conduct site investigation according to the degree of contamination, the scope of contamination, size, characteristics of the contaminated area, etc. 2. Consider the various operation and maintenance issues, various reactions, and health and safety issues. 3. Consider the limitations of the investment, cost and time factors, the ease of construction of the structure, etc. 4. After evaluating the groundwater pollution is mainly manifested as nitrification quality, nitrate (nitrite) salt ammonia, total hardness, sulfate content is too high, so the task is mainly to repair the total hardness. Remediation technology with reference to the groundwater flow characteristics mainly to the lower terrain of the Sangu Spring domain convergence, according to the migration of pollutants, should be the first of GaoPing City and LingCheon County within the groundwater pollution control and remediation[8-9].

4. Recommendation

(1) Adjustment of industrial structure and rationalization of industrial layout.

Various factories upstream of Gaoping City should be selected and moved, and coal mines should be shut down to cut off or reduce the pollution of surface water upstream. GaoPing city industry is mostly coal, chemical enterprises, and wastewater discharge; the pollution of surface water is very serious; governments at all levels should be the perspective of improving the water environment and actively carry out the adjustment of industrial structure and industrial layout, pollution is severe, technologically backward industries should be eliminated resolutely; In terms of industrial structure, on the basis of the existing primary industries and raw material processing industries, we should improve the deep development of products and accelerate the development of industries that consume little water.

(2) Enhancement of sewage treatment to meet discharge standards.

The treatment of urban domestic and production wastewater should be strictly controlled, and the specific implementation should be monitored to avoid corruption.

(3) Implementing total water and sewage control to achieve a virtuous cycle in the water environment.

(4) Vigorously developing ecological agriculture and accelerating the treatment of surface pollution.

(5) Establishment of a sound water environment monitoring network and strengthening of supervisory monitoring[10].

5. Conclusion

This paper mainly analyses the water chemistry types and groundwater characteristics of the Renzhuang subsystem and Changhe subsystem in the Sangu spring area. It draws the water chemistry-type map of the spring area. Subsequently, the environmental pollution characteristics of surface water and groundwater were analyzed, the water pollution mechanism was analyzed, etc., and the water environment quality zoning map and the pollution degree map, as well as the corresponding contour map of the main pollution map factors, were drawn. After that, water pollution control and remediation analyses of its chemical oxygen consumption and total hardness were carried out, and water pollution control measures and methods, as well as the design of remediation programs, were proposed.This study provides some scientific basis for water pollution control and remediation, which contributes to the sustainable use of water resources. Moreover, in the future, we would like to study some water pollution drivers more deeply, the implementation effect of water pollution control measures, conduct more in-depth research on water environmental protection and modestly contribute to the protection of water resources.

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