Journal of Computing and Electronic Information Management
ISSN: 2413-1660 | Vol. 12, No. 3, 2024

GIS platform ecological water environment pollution automatic monitoring and analysis

Zicheng Cong

Department of Science and Engineering, Curtin University, Bentley, Australia

Abstract: This paper summarizes the application of GIS platform for automatic monitoring of ecological water environmental pollution. Firstly, the function of GIS platform and its combination with environmental monitoring are briefly introduced, and then the pollution status of ecological water environment is analyzed, including the source of pollution, classification and the impact on environment and human beings. This paper focuses on the application of GIS in data collection and integration, spatial distribution analysis of pollutants, simulation and prediction of pollution diffusion, design and implementation of monitoring system, etc. Through the introduction of GIS technology, the monitoring and management of ecological water environmental pollution can be realized more effectively, which provides a strong support for environmental protection.

Keywords: GIS platform; Ecological water environment; Pollution monitoring; Spatial analysis; Data integration.

1. Introduction

With the rapid advancement of industrialization and urbanization, the problem of ecological water pollution is becoming more and more serious. Modern scientific and technological means are widely used in environmental monitoring and management in order to have an effect on this problem. Among them, in the field of environmental monitoring, geographic information system (GIS) has become an important tool, and its ability to process and analyze spatial data is very strong. The GIS platform can not only integrate multi-source data, but also provide decision support for environmental protection departments, such as spatial distribution analysis and pollution diffusion simulation. In this context, this paper aims to discuss the application of GIS platform in the automatic monitoring of ecological water pollution, and the importance of GIS platform in environmental governance.

2. Introduction to the GIS platform

Geographic Information System (GIS) is a specific spatial information system, which integrates computer science, geography, remote sensing technology, cartography and other disciplines, and can collect, store, manage, analyze and display geospatial data. GIS platform is the concrete realization and application carrier of this technology, which provides users with an integrated working environment for processing data and information related to geographical location. The core functions of GIS platform include data input and editing, data storage and management, spatial query and analysis, and visual expression. Through these functions, users can easily import, edit and manage a variety of spatial data, such as topographic maps, remote sensing images, geological data, etc. At the same time, GIS platform also provides powerful spatial analysis functions, such as buffer analysis, superposition analysis, network analysis, etc. These analysis functions enable users to dig deeply into the information in geospatial data and provide support for decision-making. In addition, the GIS platform also has good scalability and flexibility, and can be customized according to user needs to meet the application needs of different industries and fields. For example, GIS platform plays an indispensable role in many fields such as urban and rural planning, environmental monitoring, traffic management, and agricultural resource survey [1].

3. Combination of GIS and environmental monitoring

Environmental monitoring is an important field of GIS technology application, and becomes more and more important with the increasingly prominent environmental problems. GIS platform provides strong technical support for environmental monitoring with its powerful spatial data processing and analysis capabilities. First of all, the GIS platform can integrate environmental monitoring data from various sources, such as meteorological data, water quality data and air quality data, and carry out unified management and visual display of these data, so as to help users have a more comprehensive understanding of the current environmental situation, but also to discover environmental problems in time. Secondly, the spatial analysis function of GIS platform in environmental monitoring is also very important. For example, the buffer analysis method can be used to determine the influence range of pollution sources on the surrounding environment; The superposition analysis method can be used to evaluate the superposition effect of multiple environmental factors. The layout and sampling frequency of environmental monitoring sites can be optimized through network analysis. At the same time, GIS platform is used to support the construction and simulation of environment model. Through the combination of environmental model and relevant geographic information, the diffusion and migration of environmental pollutants are simulated to provide scientific basis for environmental risk assessment and help formulate corresponding emergency plans. These provide the foundation and support for environmental management.

4. Analysis of the status quo of ecological water environmental pollution

(1) Sources and classification of water environmental pollution

With the development of global economy and the growth of population, the increasingly serious ecological water environment pollution has become a hot spot in the world, and the ecological water environment pollution problem in our country is becoming increasingly prominent. The sources of water environmental pollution are very extensive, including industrial pollution, agricultural pollution, domestic pollution and natural pollution sources (see Table 1).

Table 1. Sources of water environmental pollution

category	Source of pollution	pollutant
Industrial pollution	Industrial wastewater	Heavy metals, toxic chemicals
		Untreated or substandard treatment
Agricultural pollution	Chemical fertilizer and pesticide	Through surface runoff, underground infiltration into the water body
	Livestock manure, waste water	An important source of agricultural pollution
Domestic pollution	Municipal domestic sewage	Contains a lot of organic matter and nutrients
	Landfill leachate	Direct discharge without treatment leads to water pollution
Natural pollution	Soil erosion, rock weathering	Produced by natural pollutants
	Atmospheric sedimentation	Have a certain impact on water
Pollution classification	Chemical pollution	Organic matter, heavy metals, toxic chemicals
	Biological pollution	Pathogenic microorganisms, parasites
	Physical pollution	Water temperature, chroma, turbidity change

Industrial pollution: a large number of industrial wastewater untreated or substandard treatment, directly discharged into the water body, causing serious water pollution, with the rapid development of industrialization, a large number of industrial wastewater discharge. Industrial wastewater, which is difficult to degrade and poses a serious threat to water ecosystem and human health, often contains heavy metals, toxic and harmful chemicals.

Agricultural pollution: Chemical substances used in agricultural production, such as fertilizers and pesticides, will enter water bodies through surface runoff and underground infiltration due to problems such as water eutrophication and accumulation of toxic substances. In addition, the important sources of agricultural pollution also include manure and wastewater produced by livestock and poultry breeding.

Domestic pollution: urban domestic sewage and garbage leachate contain a lot of organic matter and nutrient salts, if untreated direct discharge, will lead to water pollution. With the acceleration of urbanization, the problem of domestic pollution has become increasingly prominent.

Natural sources of pollution: Pollutants produced by natural processes, including soil erosion, rock weathering and atmospheric subsidence, although less influential than man-made sources of pollution, can not be ignored.

According to the nature of pollutants, water environmental pollution can be divided into chemical pollution, biological pollution and physical pollution. Chemical pollution mainly includes organic pollution, heavy metal pollution and toxic and harmful chemical substance pollution. Biological pollution mainly includes pathogenic microorganisms and parasites. Physical pollution mainly refers to the change of water temperature, chroma, turbidity and other physical indicators.

(2) The current state of water environment pollution

At present, there are different degrees of water pollution all over the world. The direct discharge of industrial wastewater and domestic sewage without treatment has caused serious pollution to many rivers, lakes and other water bodies, especially in some developing countries, due to the lack of effective environmental laws and regulations. It is worth noting that even in developed countries, problems such as agricultural pollution and domestic pollution still exist. In China, with the rapid development of economy and the acceleration of urbanization, the problem of water pollution is becoming more and more serious. The water quality of some important rivers and lakes has seriously declined, and even ecological problems such as "water bloom" have occurred. At the same time, groundwater pollution in some areas has posed a serious threat to the drinking water safety of local residents. According to the data recently released by the Ministry of Ecology and Environment, we can see that although China has made some progress in water quality control, the problem of water pollution still cannot be ignored. The data in 2023 show that in the national surface water assessment section, although the proportion of good water quality (class I-III) sections has increased, there are still poor class V sections, and the proportion has also increased (Figure 1). The main pollution indicators include chemical oxygen demand, total phosphorus and permanganate index, which are closely related to the discharge of industrial wastewater and domestic sewage. In the water quality monitoring of the seven river basins, the northwest river, the Southwest river and the Zhejiang and Fujian river, although the water quality of most of the river basins is excellent or good, there are still some lightly polluted river basins, such as the Songhua River basin. In addition, the water quality and nutritional status of key lakes (reservoirs) are not optimistic, a considerable part of the lakes (reservoirs) are in a mild or moderate eutrophic state, and some of the lakes (reservoirs) are mildly or moderately polluted (Figure 2).

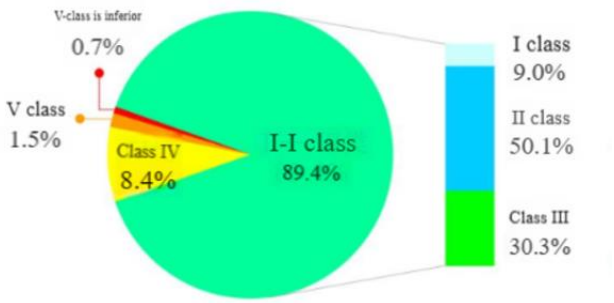

Figure 1. National surface water assessment

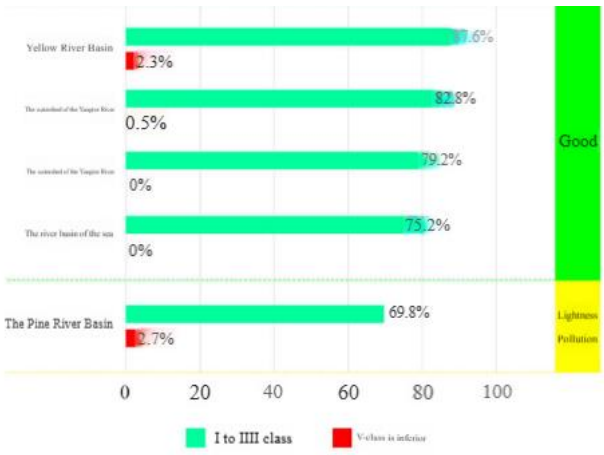

Figure 2. Proportion of water quality of some rivers in 2023

(3) The impact of pollution on the environment and human beings

Water pollution has a profound impact on the environment as well as human beings (see Table 2). First, water environment pollution will damage the balance of water ecosystems. After the pollutants enter the water body, they will have toxic effects on the aquatic organisms that cause the reduction of biological species and the decline of biodiversity, thus causing the toxic effects of aquatic organisms. At the same time, the structure and function of water ecosystems can also change due to issues such as eutrophication. Second, water pollution threatens human health. Contaminants can enter the human body through food chains that pose a hazard to human health. For example, heavy metals and toxic chemicals can accumulate in the human body, leading to various diseases; Biological pollutants, such as pathogenic microorganisms, parasites, etc., may cause the transmission of infectious diseases. In addition, water environmental pollution also brings adverse effects on economic development. Water pollution will reduce the value of water resources utilization, increase the cost of water treatment, and affect the development of industry, agriculture, fisheries and other industries. At the same time, water pollution will also cause damage to the natural landscape and ecological environment, and the attraction of tourism resources will be reduced.

Table 2. Impacts of pollution on the environment and human beings

Influence aspect	Concrete impact	Give an example	Influence object
Ecosystem	Damage water ecosystem balance	Despeciation	Aquatic organism
Human health	Threat to human health	Heavy metal accumulation	Humans
Economic development	Increase water treatment costs	The utilization value of water resources decreases	Industry, agriculture, fishing
Natural resources	Destruction of natural landscape	Tourism resources are less attractive	Tourism resources
Social life	Increased risk of infectious disease transmission	Pathogenic microorganism transmission	Social masses

5. Application of GIS in monitoring ecological water environmental pollution

(1) Data collection and integration

In the field of ecological water pollution monitoring, the cornerstone to ensure the accuracy and efficiency of the monitoring system is the collection and integration of data. In this link, GIS technology plays a decisive role, it can efficiently integrate sensor data, remote sensing images, field investigation records and other data sources, so as to build a comprehensive and accurate data set. The GIS platform integrates multi-source information such as water quality monitoring data, meteorological data, topographic and geomorphic data through its powerful data processing capability. These data are managed and analyzed in a unified manner under the geographic space framework of GIS, which facilitates subsequent spatial analysis and visualization. For example, in water quality monitoring, GIS can receive and store the latest data from online monitoring equipment in real time, ensuring the timeliness and accuracy of the monitoring system. Such data collection and integration capabilities not only improve the efficiency of data use, but also provide a solid data basis for subsequent monitoring of pollution and support decision-making. Further, GIS technology can also preprocess and clean data to eliminate outliers and noise and improve data quality. At the same time, GIS also supports the import and export of various data formats to facilitate data exchange and sharing with other systems. These features greatly improve the efficiency and accuracy of data collection and integration.

(2) Spatial distribution analysis of pollutants

In the monitoring of ecological water environmental pollution, in-depth analysis of the spatial distribution of pollutants is essential. The platform based on geographic information system can transform discrete monitoring data into continuous spatial distribution maps, so as to visually display the concentration and distribution of pollutants in different regions. The contour map based on the spatial interpolation method can deduce the overall distribution of the study area. The analysis of spatial distribution map can not only help us quickly identify pollution hotspots and pollution sources, but also form a strong basis in environmental management decision-making, so as to take timely measures for treatment and restoration, so it has a very important role in the monitoring of ecological water environmental pollution. For example, after the concentration of pollutants in a certain area is found to exceed the standard, the relevant departments can take timely treatment measures to prevent problems. In addition, geographic information system can also conduct spatial and temporal comparative analysis of historical data of pollutants, so as to have a better understanding of the development trend of pollution conditions, and provide a scientific basis for environmental planning and pollution control. The spatial distribution analysis method based on geographic information system not

only improves our cognition of pollutant distribution, but also improves our understanding of pollutant distribution. It also provides a strong technical support for environmental protection work, so it has been widely used in practical applications.

(3) Pollution diffusion simulation and prediction

The combination of GIS platform and advanced diffusion model provides accurate numerical simulation and prediction means for the diffusion and migration of pollutants, so that decision makers can react quickly when sudden environmental pollution events occur and take corresponding measures to minimize the impact on the surrounding environment and human beings. Therefore, this simulation and prediction function is of great significance. Specifically, based on the input of key data such as relevant meteorological, hydrological and terrain data, GIS can simulate the diffusion path and influence range of pollutants under different environmental conditions, so as to accurately predict the specific harm degree to the surrounding environment. Therefore, when dealing with sudden environmental pollution events, this simulation and prediction function can quickly provide decision basis for decision makers to formulate and implement corresponding emergency plans and measures. For example, the simulation and prediction of chemical emergencies is of great significance to reduce the harm to people's health. At the same time, GIS can also make effect evaluation and optimization suggestions on pollution control schemes to improve the pertinence and efficiency of treatment. With the continuous progress of technology and the expansion of application fields, GIS will be increasingly powerful in the simulation and prediction of pollution diffusion, thus playing a more important role in a wider range of ecological water environmental pollution monitoring. These predictions can help improve the pertinence and effectiveness of governance, and provide strong support and reference for environmental protection work.

(4) Design and implementation of monitoring system

Ecological water environmental pollution monitoring system is based on geographic information system technology, which is the key to realize comprehensive real-time dynamic monitoring. In the process of system design and implementation, GIS platform plays a pivotal role. In the system design stage, GIS provides designers with powerful spatial analysis and visualization tools to help them rationally plan the layout of the monitoring network, so as to ensure the representation and effectiveness of the monitoring site, and improve the efficiency of the entire monitoring system. At the same time, GIS can also help designers in data collection, transmission and processing, so as to ensure the stability and reliability of the monitoring system, that is, every link from data collection to data processing to data display has been carefully designed and optimized. Therefore, it can be said that GIS provides a powerful monitoring means for the protection of ecological water environment. In the implementation stage of the system, GIS has been integrated with various sensors and network technologies, and has achieved good results in automatic data collection, real-time transmission and online analysis. The seamless connection with mobile devices and cloud platforms brings data viewing and alarm processing functions anytime and anywhere to the monitoring system, which greatly improves the timeliness and convenience of monitoring, thus greatly simplifying the monitoring process, and to a certain extent, improving the intelligence of the entire system.

6. Conclusion

The application of GIS platform to the automatic monitoring of ecological water environmental pollution is deeply discussed, and the unique advantages of GIS platform in data collection and integration, spatial distribution analysis of pollutants, simulation and prediction of pollution diffusion, design and implementation of monitoring system are demonstrated. The introduction of GIS technology not only improves the efficiency and accuracy of pollution monitoring, but also provides strong support for the decision-making of environmental protection departments. In the future, with the further development and improvement of GIS technology, its application in ecological water environmental pollution monitoring will be more extensive and in-depth, and make greater contributions to the protection of our water resources and the environment.

References

[1] Pengsen Sun, Shirong Liu. Construction of large-scale ecohydrological model and its integration with GIS [J]. Acta Ecologica Sinica, 2003, 23(10):10.

[2] Xin Zhao. Research on monitoring and collaborative control technology of ecological environment water pollution based on GIS platform [J]. Shanxi Chemical Industry, 2022(003):042.

[3] Bin Bai,Yuwei Duan, Wu Ziren. Discussion on GIS noise environment monitoring and management [J]. Leather Making and Environmental Protection Technology, 2023, 4(11):80-82.

[4] Shuyan Zhan. Urban water ecological environment management and operation GIS map control interface : 202130338610[P] [2024-04-10].