Design of Yunnan Province Soil Environmental Quality Monitoring and Analysis Platform Based on WebGIS

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Abstract. The state and government departments will produce a large amount of soil survey data in the process of soil environmental pollution investigation. The format of soil data has diversified and multi-scale spatial characteristics. Due to the lack of a unified soil environmental pollution management platform in Yunnan Province, the storage of soil survey data is disorderly and messy. The data cannot be well-informed and scientifically analyzed, resulting in the inability to provide accurate and comprehensive soil environmental quality for all levels of government management data. In order to effectively solve this problem, taking soil heavy metal pollution survey sampling points in Yunnan Province as an example, this paper uses web geographic information systems (GIS) technology to design a set of soil environmental monitoring and analysis platforms that describe data sources, data collection, data analysis and visualization. The platform has established a scientific and rigorous data analysis method, which can uniformly convert and store historically scattered data and conduct unified management and analysis of survey data.

1. Introduction
With the increasing prosperity of the economy and the acceleration of the process of industrialization, various environmental problems have gradually emerged. As one of the basic elements of the ecological environment, soil is the material basis for sustainable economic and social development, and it is related to the health of the people. Since the last century, Yunnan Province has begun a multi-scale soil environmental survey. Due to the long span of data, scattered in the hands of various departments, without data integration and unified standardized management, a large amount of soil resource data has not been informatized, resulting in poor accuracy and reliability of soil environment-related data, which cannot be used at all levels. The management department provides accurate and comprehensive basic data, which cannot fully reflect the soil environmental quality and its changes in Yunnan Province. In order to grasp the distribution characteristics of the characteristic pollutants in key soil pollution risk areas, a soil environment visual monitoring and analysis platform that improves the management efficiency and management level of the environmental monitoring and management departments of Yunnan Province is needed. The platform can provide comprehensive and accurate basic data and scientific decision support for soil pollution prevention and soil ecological restoration in Yunnan Province.

After studying the existing soil heavy metal pollution assessment and monitoring information system, it is found that most systems not only still use the past technology, but also stay at the traditional desktop geographic information systems (GIS) stage. This kind of development system often has poor flexibility and scalability, single display effect and slow data update, which cannot
meet the update and processing requirements for massive data. Compared with traditional GIS, WebGIS has the characteristics of wide access range, cross-platform, low cost, high efficiency, real-time update and so on [1]. In recent years, with the rapid development of the Internet, WebGIS has been widely used in many fields, including resource transportation, environmental assessment, disaster prediction, terrain management, urban planning, post and telecommunications, national security, water conservancy and electricity, public facilities management. [2-4]. In terms of ecological and environmental management and simulation, WebGIS is mainly used for regional ecological planning, environmental status assessment, and environmental impact assessment. It also provides decision support for pollution reduction, regional sustainable development, environmental protection facility management, environmental planning, etc. [5].

After analyzing the existing technology, this article finally adopted the latest architecture and technical route, got rid of the traditional ArcGIS Server solution, and adopted lightweight NodeJS, VueJS, and ArcGIS API for JavaScript, ECharts, GeoJSON and other construction platforms. This technical solution realizes a series of subsystems such as integration, dynamics, and visualization. The subsystems can be linked and analyzed to carry out high-performance analysis transmission and visual display for massive survey data, which greatly improves the efficiency of analysis and monitoring. This further improves the analysis capabilities of the Yunnan Provincial Environmental Monitoring Center Station for soil environmental monitoring of organic matter, heavy metals, and soil emergency.

The platform is not only high-performance and lightweight, but also has strong versatility and portability, and can provide technical standards and specifications for other environmental pollution monitoring platforms. In addition, after the platform development is completed, it will be built into a docker image and uploaded to the warehouse. This approach not only enables rapid delivery and deployment of the platform, but also makes it easier to migrate and expand the platform.

2. Key Web Technologies

Since the data of soil environmental pollution has spatial and geographic attributes and needs to be displayed on the web, this platform is a typical WebGIS platform. WebGIS is the product of applying Web technology to GIS development. Generally speaking, it is developed by the B/S model, which has the advantages of low development cost and high development efficiency. It is currently an important direction of GIS development [6]. In order to achieve faster development speed and better performance, the technology stack adopted by this platform is mainly based on the technology on the NodeJS platform of JavaScript. The following are the key technologies used in the development system:

- **NodeJS**: NodeJS is an event-driven I/O server JavaScript environment based on Google’s V8 engine which is running on the server. Because the V8 engine has excellent JavaScript parsing capabilities, NodeJS has the advantages of fast speed and good performance.
- **ECharts**: ECharts, an open-source visualization library implemented using JavaScript, can run smoothly on PC and mobile devices, compatible with most current browsers, and the underlying layer relies on vector graphics.
- **OracleDB**: It is the NodeJS version that accesses the Oracle Database API, which provides support for high-performance Oracle database applications. Node-OracleDB supports basic and advanced functions of Oracle database and Oracle client.
- **ArcGIS API for JavaScript**: ArcGIS API for JavaScript is a set of programming interfaces written by ESRI in the JavaScript language. Users can access the services provided by ArcGIS server by calling the API, such as creating, browsing, editing, rendering maps, and some commonly used spatial analysis functions.
- **GeoJSON**: A format for encoding data about geographic features using JavaScript Object Notation (JSON) [RFC7159]. GeoJSON provides a means of representing both the properties and spatial extent of features. GeoJSON today plays an important and growing role in many spatial databases, web APIs, and open data platforms. Consequently, the implementers
increasingly demand formal standardization, improvements in the specification, guidance on extensibility, and the means to utilize larger GeoJSON datasets.

3. System Architecture

3.1. Overall system architecture

The main purpose of the soil environmental monitoring and analysis platform in Yunnan Province is to integrate and apply soil pollution data in Yunnan Province, and complete the visual display functions of browsing, displaying, spatial analysis, and analysis and evaluation of soil pollutant survey projects. Provide technical support for the geospatial display and analysis of soil environmental pollution in Yunnan Province. According to the above main functions and core business requirements, the platform is developed on the basis of the B/S architecture, using the front-end and back-end separation method, and the front-end GIS interface is constructed with modern componentization ideas.

As shown in Figure 1, the entire system is divided into the following architectures: user layer, presentation layer, service layer, logic layer, and data layer.

![System overall architecture diagram](image)

3.2. System function design

The data used in this article is a large amount of basic data from the soil environmental survey at the Yunnan Environmental Monitoring Center. In order to better display, store, manage, use and analyse the environmental survey big data, from the perspective of platform development, the overall architecture of the integrated system is mainly divided into four main parts: data management, data interaction, data analysis and data display. Each part is designed to be independent and can be connected to each other through interfaces. In the overall structure, the data management part provides management spatial data, environmental survey data, analysis data, and so on. And realize basic operations such as adding, deleting, modifying and viewing data. Data interaction is mainly based on the user's requirements for basic operations on the map to provide users with basic interactive display and regional frame selection, movement, query, and pop-up functions. Data analysis ranks the pollution degree of the area selected by the user, and provides a result download function. The data display can display the pollution analysis data results in point-by-point display, heat map display and three-dimensional display. The functional structure diagram is shown in Figure 2.

3.3. Unified database design

The basis for the platform to achieve data unification is to build a unified database standard, and then the data can be managed and operated, which include data storage, maintenance, extraction and
integration. Therefore, efficient storage and management of massive and distributed geospatial data is the key to the success of WebGIS. At the beginning of the design of the system, the data is standardized and customized, and Oracle enterprise-level database is selected for storage. In addition, it can be improved and expanded according to the nature of different soil pollutants.

Due to the redundancy of historical data, the amount of soil pollution data is huge, and the data format is complex and diverse. The data standard after the unified design of the platform can accurately cover the various spatial and attribute information of the soil, and can be compatible with the historical soil data.

4. System Implementation Method

The platform design needs to follow the web application design principles as much as possible: practicality, reliability, maintainability, and security [7]. The main function of the WebGIS platform is to perform a series of operations such as interactive analysis of spatial information with users. The interaction between the soil environment monitoring and analysis platform of Yunnan Province and the user is mainly completed by the display layer, and its display layer is composed of a GIS subsystem and a visualization subsystem. The implementation of these two subsystems will be described below.

4.1. GIS subsystem

As the entire platform should reduce development costs as much as possible, rapid development to maximize benefits. The base map used by the GIS subsystem is based on public resources on ArcGIS Online. There are no restrictions on the access of resources in the local area network, as long as they can access the network, they can be displayed. The remaining spatial analysis of the subsystem, as well as data query, area measurement, area analysis and other functions are all realized by the front end, which is commonly known as the "fat" client. The backend only provides the basic data API interface of the project, and does not involve any spatial operations. This matching method greatly simplifies the coupling of the system. The front-end functions implemented in the entire GIS subsystem mainly use the Map and View classes in ArcGIS JS API, as well as the Widget class. According to the idea of componentization, the above-mentioned class library is encapsulated into a component of VueJS through the CommonJS import method for use. The main interaction method is to make Ajax requests to the backend by switching between different survey items. The back-end converts the standard data of the database into a standard GeoJSON format with spatial and geographic attributes according to different routes and parameters, and then transmits it to the front-end for rendering. After the data is rendered, you can see the detailed geographic location of each soil sampling point on the satellite image base map. Click on the point, and the detailed information of the point will pop up, including altitude, sampling location, topography, and sampling location Carousel of orientation maps and so on.

4.2. Visualization subsystem

The visualization subsystem is the subordinate system of the GIS subsystem, which can analyse the pollution in the designated area. The analysis steps are as follows: First, click the drawing component in the upper right corner of the GIS subsystem, and this component can freely frame and select an area that you want to analyse. Secondly, the evaluation criteria for pollutants are specified, such as the soil pollution standards for agricultural land in China. Finally, an analysis method is selected to analyse the area. Commonly used analysis methods include single factor analysis, multifactor analysis, Nemero Pollution Index Method, AHP and so on.

The results of analysis and evaluation can be downloaded or displayed visually. There are three ways of visual display: the first is the point map, this display method can accurately display the pollution samples. This implementation is to set the pollution rendering method to intermittent display.

The second visualization method is the heat map. The heat map can roughly show the distribution of pollution in the selected area, which helps to make auxiliary decisions on pollution control in the
area. The way to achieve this is to change the rendering method of pollution points to color superimposition according to the scale of pollution.

The third visualization method is to display the results of the previous analysis in a 3D histogram according to its altitude and pollution level. It is mainly realized through ECharts. This method is also based on the analysis results to set the field properties to be rendered for visual display.

5. Platform Function Display

Based on the above structure and function design, the GIS subsystem is shown in Figure 3 below. The upper left corner of the figure is the control panel, which can perform project selection and basic query positioning functions. For a large amount of survey data, the system will perform statistics and cluster display to make the platform more intelligent. The upper right corner of the GIS subsystem is a drawing tool widget, which supports circle, square, and hand-drawn curve methods to divide the project area. As shown in Figure 4.

The sample point map is a detailed display of the analysis results and classification of pollution levels. Click the analysis result sample point, the system can display a pop-up window, showing the monitoring information of this point in detail, as shown in Figure 5. The heat map is a visual interface that uses blocks of different colors to be superimposed on the map to describe the distribution and change trend in real time, and it has strong intuitiveness. This method can show the trend and distribution of pollution, and provide users with timely analysis and judgment. The system interface is shown in Figure 6.

The three-dimensional (3D) map can show the distribution of pollution more intuitively than the heat map. It has one more rendering field than the heat map, and can correspond to the height of the column in the map according to the altitude. The 3D map can show more hidden information and get more pollution data. The system interface is shown in Figure 7.
6. Conclusion
This paper designs a WebGIS platform for soil environmental monitoring and analysis, and uses soil heavy metal pollution in Yunnan Province as an example to perform analysis and display. Because this platform is lightweight and versatile, it can be widely used in various environmental pollution GIS systems after development. In addition, the system also provides a new technical standard and establishes a good soil pollution data analysis platform. Using this platform to process soil pollution data can effectively reduce the cost of information construction and operation, directly generate economic benefits, improve the management efficiency and management level of the management department, and provide comprehensive and accurate basic data and scientific decision support for the restoration of the ecological environment.

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