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Discussions about Construction of Agricultural Ecological Geochemical Survey Database

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Abstract [**Objectives**] To realize proper, update and dynamic analysis of the results of ecological geochemical survey, and provide useful information for government macro-decisions, land resources planning, agricultural structure adjustment, ecological environment monitoring, governance and evaluation. [**Methods**] This paper conducted the analysis with the aid of the computer database technology and GIS technology, as well as the regional geochemical database information system (GeoMDIS) developed by the Development Research Center of the China Geological Survey. [**Results**] It established a database of agricultural ecological geochemical survey in the lower Yellow River Basin of Shandong Province, realized the collection, storage, update and statistical analysis management of various sample data. [**Conclusions**] Through the discussion on the construction of agricultural ecological geochemical survey database, it is expected to provide an effective information platform for the future use of these data to serve government macro-decisions, land and resource planning, agricultural structure adjustment, ecological environment improvement, monitoring, governance and evaluation.

Key words Agricultural ecological geochemistry, Spatial database, Geographic information system

1 Introduction

With the constant improvement of the market economy and the continuous expansion of economic and social development demands, geological work must not only provide resource protection, but also take into consideration environmental issues; not only to continue to serve industrial construction, but also better and more serve agricultural development, so as to realize the coordinated development of economic society with resources and environment[1]. The project of "Ecological Geochemical Survey of the Lower Yellow River Basin in Shandong Province" is a special survey and evaluation of the ecological geological environment based on the agricultural regional geochemical survey. The database construction is a fundamental work in the entire project. A regional ecological geochemical database was established using the analysis and test data of a large number of samples of soil, lakes and near-shore water sediments and water and other media obtained from the agricultural ecological geochemical survey of the lower Yellow River Basin in Shandong Province, as well as regional basic geology and other information, in accordance with relevant regulations and requirements. It can make better use of these data, provide useful information for government macro-decisions, land resources planning, agricultural structure adjustment, ecological environment monitoring, governance and evaluation, and finally realize the use, update and dynamic analysis of ecological geochemical survey results[2].

2 Process of database construction

The construction of the agricultural ecological geochemical survey database for the lower Yellow River Basin of Shandong Province was undertaken through comprehensively collecting and arranging the project deployment map, sampling site map, combined sample site information, map work information, geochemical analysis data, environmental background survey data, analyzing quality monitoring data and field record card, taking the geochemical theory as guidance, and making a comprehensive analysis and research on existing data. The database construction took MapGIS and Access as information platform, with reference to the national and industry standards and specifications, such as *Specification for Multi-target Regional Geochemical Survey*, *Technical Requirements for Regional Ecological Geochemical Evaluation*, *Technical Requirements for Ecological Geochemical Evaluation Sample Analysis*, and *Technical Requirements for Construction of Multi-Target Regional Geochemical Database*. The specific process of this database construction work is illustrated in Fig. 1. (i) Collecting and organizing related data, focusing on the integrity of the data; (ii) pre-processing the data, focusing on the clarity and correctness of the data records; (iii) inputting the data, using the "multi-target geochemical input system (V2.2) released by Development Research Center of the China Geological Survey"; (iv) establishing a database, focusing on the logical correspondence relationship with the data stored in the database; (v) summarizing and sorting out the data and documents and submitting the results.

3 Database construction

3.1 Sampling distribution attribute information storage

A database of soil sampling sites for ecological geochemical surveys in the lower Yellow River Basin of Shandong Province was established in accordance with the requirements of the *Interim Provisions for Multi-Target Geochemical Surveys in Coverage Areas* issued by the China Geological Survey. The database was designed

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to be Access format, to input the contents of the sampling record card, and develop functions for querying, classifying, extracting, and supplementing various contents in the database. It designed the "Multi-target Geochemical Survey Soil Sampling Site Record Card" for the Agricultural Ecological Geochemical Survey Database in the lower Yellow River Basin of Shandong Province as shown in Fig. 2, as the main interface for sampling point data input, and established 34 data items according to requirements. Besides, four relational attribute connection tables, namely, soil sampling record table, administrative division table, soil type table, accumulation type table, repeated sample table, were established in the database, and the content of each table linked the corresponding data item in the main interface. In the same sampling map, the contents of most attribute data items of adjacent sampling points were basically the same. In order to save data input time, the program has been specially designed. Just press the "New Record" button, 14 items (map number, administrative area, sampling horizon, sampling depth, color, location, environment type, accumulation type, material source, vegetation, pollution, groundwater level, salinity, soil erosion) can automatically carry on the content of the previous record. Based on this, the input personnel modify the data items with different individual contents according to the actual sampling situation, which greatly improves the input efficiency.

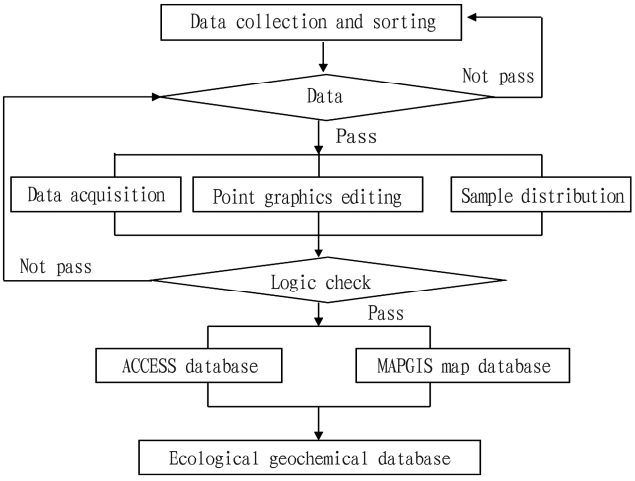

Fig. 1 Work flow of construction of agricultural ecological geochemical database for the lower Yellow River Basin of Shandong Province

The description items filled in the field sampling record card were prepared in accordance with the provisions of *Specification for Multi-target Regional Geochemical Survey*. When establishing the database, the ACCESS database structure of various field sampling databases was established according to the types of data items defined in the *Technical Requirements for Construction of Multi-Target Regional Geochemical Database* with reference to the description items in the field record cards. In the stage of establishing the database structure, data input rules were set for some of these items to avoid inputting some wrong data of common sense. In addition, according to the *Specification for Multi-target Regional Geochemical Survey*, repeated samples should be taken at a certain rate during field sampling to control the sampling quality and analysis quality. For soil samples, due to the huge number of samples, more than two sets of repeated samples often appear in the same sampling map. In order to successfully extract repeated samples from many samples for quality inspection, the data items of "original sample number" in *Technical Requirements for Construction of Multi-Target Regional Geochemical Database* were further detailed when the database was established, and was clearly stipulated to fill in the form of "B077A (11), B077A (12), B077A (21) and B077A (22)", and defined the meaning of the repeated code and the meaning of the code in parentheses after the sample number shown, for example, code 11 means the first analysis of the first sampling, code 12 means the second analysis of the first sampling, code 21 means the first analysis of the second sampling, and code 22 means the second analysis of the second sampling. Also, it was stipulated that for the sampling records without corresponding repeated samples, the column of "original sample number" data item should be left blank. In this way, it can be ensured that when needed, repeated samples can be quickly selected from the sampling records of many samples, and the repeated samples can be correctly distinguished by group.

Fig. 2 Multi-target Geochemical Survey Soil Sampling Site Record Card

图幅代号	GPS ID号	样号	横坐标	纵坐标	样品组份	名称	颜色	取样深度
J50E023014	B001A	001A1	20522588	4021621	012	3	4	20
J50E023014	B001B	001B1	20523245	4021575	012	3	4	20
J50E023014	B001C	001C1	20522733	4020493	012	3	4	20
J50E023014	B001D	001D1	20523444	4020369	111	2	4	20
J50E023014	B002A	002A1	20524634	4021516	013	3	4	20
J50E023014	B002B	002B1	20525483	4021434	012	3	4	20
J50E023014	B002C	002C1	20524362	4020685	013	3	4	20
J50E023014	B002D	002D1	20525361	4020346	013	3	4	20
J50E023014	B004A	004A1	20526737	4021272	121	3	4	20
J50E023014	B004B	004B1	20527222	4021382	211	3	4	20
J50E023014	B004C	004C1	20526474	4020350	121	3	4	20
J50E023014	B004D	004D1	20527450	4020539	013	3	4	20
J50E023014	B005A	005A1	20528461	4021362	013	3	4	20
J50E023014	B005B	005B1	20529579	4021501	121	3	4	20
J50E023014	B005C	005C1	20528445	4020521	112	2	4	20
J50E023014	B005D	005D1	20529521	4020544	121	3	4	20
J50E023014	B006A	006A1	20530477	4021591	013	3	4	20
J50E023014	B006B	006B1	20531500	4021507	013	3	4	20

Fig. 3 Text file with coordinate values exported by ACCESS

3.2 Quality inspection of the input content of the field sampling record card The field sampling records used for entry and construction of the database are subject to a three-level quality inspection. The map is used as the unit when entering. Each map is recorded and must be inspected to ensure the accuracy of the sam-

pling data. Apart from manually checking the consistency of the input sampling information and the field sampling record card, the software can also be used for machine inspection. For example, export the TXT file with the vertical and horizontal coordinate values, sampling point number and map number from the ACCESS database, as shown in Fig. 3; use the "projection conversion module" in MAPGIS to convert the input sampling points to generate point files with attributes; use the "annotate according to attributes" function in MAPGIS to mark the sample number and the map number of the sampling point beside each sampling point; use the "automatically generate standard frame" function in MAPGIS to generate the standard frame of the input map; finally, combine the standard frame of the map and the point file generated in the previous step, to form a sampling point bitmap, and check against the actual field material map. In order to ensure that the quality inspection obtains the due effect, the personnel who input the sampling data are required to make a record of the problems found in the input process in time, and the analysis of the cause of the problem, the processing method, the results and the processing basis. It can be in the form of paper media or electronic documents, and the input personnel must sign on the daily inspection record. Besides, according to the quality inspection regulations of the Shandong Institute of Geological Survey, mutual inspection and random inspection of the sampling input data should be carried out, and the inspection results should also be recorded; in order to facilitate the storage and inspection, all levels of inspection records must be formed in an electronic file format.

3.3 Input of information of sample test analysis results For the analysis data of agricultural ecological geochemical survey samples in the lower Yellow River Basin of Shandong Province, the following three conditions must be met before the data input: (i) the data must pass the sample analysis quality review; (ii) the data must pass the project team and test analysts in accordance with corresponding specifications and technical requirements and eliminate systematic errors; (iii) the data must eliminate errors between analyzed batches. When collecting samples in the field during the agricultural ecological geochemical survey in the lower Yellow River Basin of Shandong Province, the samples shall be numbered and recorded in accordance with the unified regulations. After the samples are put into the warehouse and processed according to the regulations, the samples sent to the laboratory should be numbered separately. The sample number compiled for the analysis in the laboratory is called the analysis sample number.

In the samples collected in the field of the agricultural ecological geochemical survey in the lower Yellow River Basin of Shandong Province, some types of samples have the same sampling number as the analysis sample number, so that a corresponding relationship can be established directly between the sampling record and the analysis result record. However, for some types of samples, the sample number is not consistent with the analysis sample number for reasons such as confidentiality or to make the analysis sample number shorter to reduce the chance of errors. For this situation, in order to establish the corresponding relationship between sampling records and analysis result records, it is necessary to establish an additional "Sampling Number and Analysis Sample Number Comparison Table" in the ACCESS database as shown in Fig. 4. In the comparison table, the "sampling number" and "analysis sample delivery number" are external key fields to establish the corresponding relationship between the sampling record and the analysis result record shown in Fig. 2 and Fig. 3. Then, it is necessary to check the consistency between the number of samples and the number of samples sent according to the corresponding relationship between the sampling record and the analysis result record, and process the detected missed and unanalyzed samples according to regulations. For the analysis data of the repeated samples, the analysis data of the repeated samples will be selected separately when establishing the database, to form an ACCESS repeated analysis sample data table for checking the analysis quality of the samples according to the technical specifications. In addition, in the sample analysis data table, it is necessary to keep the data results of the first analysis and the first analysis of the repeated analysis samples, to make a similar plotting to check the quality of the analysis data. After the sampling point attribute information and sample test analysis result information are input into the database, regardless of whether they are in EXCEL format or ACCESS format, they will eventually be imported into the "multi-target geochemical input system (V2.2)" released by Development Research Center of the China Geological Survey. Through this import process, you can further check the standardization of the contents of the database.

Fig. 4 Establishing the corresponding query of sampling records and analysis records

3.4 Map plotting The geochemical survey maps for agricultural multi-target regions in the lower Yellow River Basin in Shandong Province were plotted in strict accordance with "geochemical map preparation" provisions of *Geochemical Exploration Map Scheme*, *Legend and Color Standard* (DZ/T 0075-1993) and *Specification for Multi-target Regional Geochemical Survey*. In order to ensure that the maps can meet the requirements of the specifications, and achieve a unified and beautiful effect, the project team printed some common content (Table 1) in the specification and distributed it to each map plotting person for reference and implementation.

Table 1 Provisions on maps of sampling points in bitmap

Bitmap category	Point subplot representation			Sampling point representation	
	Subplot	Specification	Color	Specification	Color
Surface soil geochemical sampling point	Circle	D 2 mm	Black	1×1.5 mm	Black
Deep soil geochemical sampling point	Double circle	D 2 mm	Black	1×1.5 mm	Black
Surface geochemical sampling points in tidal flats (including intertidal zone)	Triangle	L 2 mm	Green	1×2.0 mm	Green
Deep geochemical sampling points in tidal flats (including intertidal zone)	Double triangle	L 2 mm	Green	1×2.0 mm	Green
Sampling points of surface sediments at the bottom of the lake and surface sediments in the coastal waters	Circle	D 2 mm	Dark blue	1×1.5 mm	Dark blue
Sampling points of deep sediments at the bottom of the lake and deep sediments in the coastal waters	Double circle	D 2 mm	Dark blue	1×1.5 mm	Dark blue
Surface water geochemical sampling point	Circle	D 2 mm	Bright blue	1×1.5 mm	Bright blue
Shallow ground water geochemical sampling point	Double circle	D 2 mm	Bright blue	1×1.5 mm	Bright blue

In addition, the project team also uses unified mapping software and system libraries to name and express the contents of the layer files that make up each map; this basically guarantees the consistency of the representation of the maps. On this basis, the project team can refer to the related content in the completed maps, which not only reduces the workload and increases the efficiency, but also helps to ensure the consistency and accuracy of the maps. The process for plotting the sampling point bitmap is specified as follows: first, the TXT attribute text is converted from the ACCESS sample point data; second, the TXT attribute text is used to generate the attribute point map in MAPGIS; third, the generated point and standard map frame are combined with geographic content to form a complete map. In the process of generating MAPGIS files by TXT attribute text conversion through the system, the automatically generated attribute structure is fixed, and some fields are not long enough to receive all the attribute content. It is necessary to place at MAPGIS "projection transformation" – "set separator", and reset the field length according to the length of each item description. Using this working method, a series of basic maps such as series of elements and indicators geochemical maps such as soil, shallow groundwater, sediments in coastal areas and the distribution of persistent organic pollutant residues in the survey area were compiled in accordance with relevant specifications. These maps comprehensively and objectively reflect the regional distribution characteristics and changing rules of element and indicator geochemistry of different media, and provide basic data for carrying out agricultural ecological geochemical evaluation and overall comprehensive research in the lower Yellow River basin of Shandong Province.

3.5 Database management and maintenance The types of agricultural ecological and geochemical databases in the lower Yellow River Basin of Shandong Province include vector spatial data, rasters, documents, photos, videos, *etc.* According to their research level, the database can be divided into two types: basic area background survey data and thematic data. According to its research content, the database can be further divided into several sub-databases, namely sub-database of geographic information data, sub-database of geochemical data, sub-database of geological data, sub-database of agricultural safety data, sub-database of non-point source pollution data, and sub-database of document data. The grid data in the agricultural geological environment information data includes digital elevation model (DEM) and remote sensing image, which have multi-resolution and multi-format features. The agricultural geological environment information database uses a mixed management raster data management method that supports files and relational database systems. The ARCSDE grid and vector integrated management mode is used in the relational database to manage massive data and multi-user access, and file system management is adopted for local data. In order to manage and maintain the database in a safe and effective manner, the system database uses SQL Server2000 database. Management and maintenance are undertaken as per spatial database, attribute data and meta-database. The system is provided with legal database users, who can define the data structure, work on data transfer, calculation and data access[3]. Data security and confidentiality are guaranteed by setting up a network firewall to control access by non-administrative users[4].

4 Database application

The database of agricultural ecological geochemical survey in the lower Yellow River Basin of Shandong Province was established on the basis of millions of high-precision multi-element geochemical analysis test data obtained through multi-element geochemical surveys of agricultural surface soil, deep soil, shallow groundwater and near-shore shallow seabed deposits in the lower Yellow River Basin of Shandong Province. It is an important data source for agricultural ecological geochemical survey projects in the lower Yellow River Basin of Shandong Province. Through systematic statistical analysis and research, a series of geochemical characteristic parameters, geochemical reference values and background values mainly composed of soil and shallow groundwater were established, and a series of 1∶250 thousand agricultural ecological geochemical maps in the lower Yellow River Basin of Shandong Province was formed, which has laid a solid foundation for the realization of multi-field comprehensive services of agricultural ecological geochemical survey results in the lower Yellow River Basin of Shandong Province. Furthermore, the construction of database of agricultural ecological geochemical survey in the lower Yellow River Basin of Shandong Province has a great strategic significance for the overall comprehensive evaluation of the agricultural ecological geochemical environment in the lower Yellow Riv-

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moved by traction. It is environmentally friendly and pollution-free. It has the characteristics of high safety, automation and high production efficiency. Also, crushed materials can be used as edible fungus culture medium, animal feed, organic fertilizer, *etc.*, and can be further compressed into biomass fuel, and the crushed branches can be returned to the field.

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er Basin of Shandong Province, urban ecological geochemical environmental zoning and early warning, forecast, ecological effects and management plan research, agricultural ecological Chemical zoning, as well as the research on high-quality and efficient agriculture and its development strategies[5].

5 Conclusions

With the implementation of the agricultural ecological geochemical survey in the lower Yellow River Basin in Shandong Province, the construction of the ecological geochemical survey database in the lower Yellow River Basin in Shandong Province sorted out and collected the information and laboratory analysis data of various samples, and built the sample geology sampling database and analysis test data of the ecological geochemical survey database in the lower Yellow River Basin of Shandong Province; submitted MAPGIS format sample layout points of various types of samples with geographic content, combined sample point distribution maps; developed a set of suitable working technology methods, including comprehensive technology synthesis, information systems and results expression methods, *etc.*, which have also been widely applied in other ecological geochemical survey projects.

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