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Well-Drilling and Groundwater Monitoring Network Construction: Taking Changde City as an Example

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Abstract: Entrusted by the Environmental Protection Bureau of Changde City, we conducted drilling, sampling survey and constructed a monitoring network for groundwater in several counties and districts of Changde City. This article introduces the drilling technology, detection method and detection network layout plan adopted in the project, and expounds the problems that occurred while executing the project, in order to provide reference for similar groundwater capacity supervision and construction projects.

Keywords: Groundwater; Well-drilling; Monitoring network; Changde City

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1. Introduction

From the 1950 s to the 1980 s, China embarked on a gradual process of groundwater monitoring and control. However, the phenomenon of imprudent development and utilization of groundwater in various regions of the country has resulted in frequent geological disasters[1]. Since the beginning of this century, the Ministry of Land & Water Resources has deployed over 20, 000 groundwater monitoring points throughout the nation, contributing to the establishment of our country' s groundwater monitoring network. However, due to the different conditions in various provinces and cities, the progress of groundwater monitoring network deployment is also inconsistent. Guangxi Province started groundwater monitoring in 1981, and a total of 431 third-level groundwater monitoring stations have been built by 2017[2]. As one of the provinces with the most water shortage in China, more than 1, 200 groundwater monitoring stations have been built in Shanxi Province[3].

Shandong Province was among the earliest regions in China to initiate the establishment of groundwater monitoring networks[4]. By the end of 2017, the Provincial Land and Resources Department had amassed a total of over 2, 200 groundwater monitoring points[5] in order to control their groundwater resources. Compared with provinces that implemented groundwater control earlier, Hunan Province first started groundwater monitoring in Shaoshan City in the 1970 s, and it spread throughout the province. Until now, the Ministry of Natural Resources of Hunan Province possess only more than 300 groundwater monitoring stations, which is only half of the average number of monitoring stations among all provinces in China. The comprehensive deployment of monitoring stations across most areas of the province has not been achieved. Therefore, the national requirements for management and control for groundwater resources have not been met. Therefore, this makes the construction of groundwater monitoring stations in Hunan

Province a crucial issue[6]. Changde City is located in the northwest of Hunan Province, with 2 districts, 6 counties and 1 city under its jurisdiction. The Changde City Ecological Environment Bureau actively carried out the construction of groundwater supervision capacity, and compiled the "Changde City Groundwater Supervision Capacity Building Project Plan." On one hand, this plan was initiated in response to the Ministry of Ecology and Environment's "Notice on the Construction of the Central Environmental Protection Investment Project Reserve Bank in 2019 (Huan Ban Ke Cai Han [2019] No. 474)." On the other hand, the plan serves to increase the number of monitoring stations in the region to form a more comprehensive environment and a complete monitoring network.

2. Drilling technology

In order to have a clearer understanding of the overall groundwater pollution in Changde City, several counties and districts have built new monitoring wells for the basic environmental conditions of groundwater and groundwater monitoring wells to detect pollution sources. Many infill wells have been built in large-scale industrial parks or landfills that produce pollutants, which are mainly used for single sampling to detect the quality of groundwater, and the wells will be backfilled and sealed after the sampling is completed. Groundwater quality monitoring wells are constructed at pollution sources in full compliance with national standards, and are used as permanent facilities to monitor groundwater quality in the area in real time.

Due to the different specifications of the two types of wells, the drilling techniques and materials used are also different. The pores of infill wells have a single-tube single-layer structure, and the depth of the pores depends on the water-bearing depth of the groundwater. The diameter of the well was 110 mm, and the diameter of the pore was 50 mm. The pipe material is polyvinyl chloride (PVC), the water supply pipes were also made of PVC. The method used for drilling into the quaternary loose layer involved dry drilling with a Φ127 mm drill bit. Rotary drilling with casing follow-up was used for the gravel layer; after reaching the bedrock layer, a Φ108 mm diamond drill bit was used to drill to the design depth through normal-circulation rotary drilling. After the coring was completed, the Φ220 mm tri-cone bit was used instead of the anti-deviation drilling tool to pressurize and anti-deviation drilling process for reaming. The monitoring well also had a single-pipe and single-layer structure, and the depth of the hole depended on the depth of the groundwater. The diameter of the well was 358 mm and the diameter of the hole was 146 mm. The well pipe consisted of three parts: the well wall pipe, the filter pipe, and the sedimentation pipe. The well pipe was made of stainless-steel with a thickness of not less than 4.5 mm. The length of the sedimentation pipe was not less than 3 m, the length of the filter pipe was the same as the thickness of the aquifer, and the wall pipe extended more than 50 cm from the wellhead. In terms of drilling methods, the quaternary loose layer was drilled using the dry-drilling method with a Φ127 mm drill bit. For the gravel layer, the rotary drilling method was used followed by casing follow-up. After reaching the bedrock layer, a Φ108 mm diamond bit was used. The normal-circulation rotary drilling is used drill to the designed depth. After the coring was completed, the quaternary loose layer was reamed using a Φ350 mm tri-cone bit biased anti-deviation drilling tool pressurization and anti-deviation drilling technology. The bedrock section was drilled with a diamond bit and normal-circulation rotary drilling, and the final hole diameter of the bedrock section was not less than Φ110 mm.

The construction of monitoring wells is more complex in terms of materials and procedures compared to infill wells, and it requires the construction team to make correct judgments on-site based on field conditions. During the construction of the monitoring wells of this project, PVC-U was originally selected as the material of the monitoring wells, which was consistent with the survey wells, and the selection of such materials is also in full compliance with the "Code for Construction of Groundwater Monitoring Wells"

(DT/Z 0270-2014) requirements. However, during the actual construction process, the first monitoring well had a cross-hole after the final hole was drilled, and the PVC-U pipe could not bear the pressure of the surrounding soil layer and was distorted and deformed. Through multiple discussions among experts, it was proposed that the reason for this phenomenon should be that there are many thick underground sand and gravel layers in many areas of Changde. This is also consistent with the conditions of the cores taken out, and the pressure on the pipes is relatively high, resulting in engineering problems. Therefore, the material for the monitoring well pipe was changed to stainless steel. This incident provided very valuable experience for the construction of monitoring well in Changde City.

3. Sampling and detection

In the groundwater supervision and capacity building project in Changde City, to fully understand the groundwater pollution in the monitored area, a comprehensive detection of the pollution factors of each block was carried out based on the "Investigation Information and Risk Screening Report of Enterprises in Key Industries in Hunan Province" in addition to the routine quality indicators of groundwater stated in the "National Groundwater Quality Standards" (GB/T14848-2017).

The sampling mode and frequency of all newly-built monitoring wells were sampled once, and the wells were sealed right after the sampling is completed. 18 monitoring wells needed to be regularly sampled and maintained. The monitoring wells are sampled once a quarter manually to form a quarterly inspection report, and four times throughout the year to form an annual inspection report. Through the comparative analysis of the four quarterly reports, we can have a clearer understanding of the migration and transformation of groundwater pollution factors in each monitoring block.

In terms of groundwater quality sampling methods, the water samples used are grab samples. Before each sampling, on-site swabbing is carried out through a Baylor tube. The amount of swabbed water must be twice the volume of the accumulated water in the well, and the sampling depth should be below 0.5 m of the groundwater surface to ensure that the water samples taken reflects the groundwater quality in the area. In addition, some indicators are measured on-site. For -indicators that cannot be measured on-site, the samples will be stored in strict accordance with the national sampling and testing standards and sent to a laboratory for testing within a specific period[7].

The national or industry standard method always come first in groundwater quality detection and analysis. For indexes without a standard analysis method, a unified industry analysis method can be used. When other equivalent analytical methods for other bodies like the International Organization for Standardization (ISO), the United States Environmental Protection Agency (EPA), and the Japanese Industrial Standards (JIS) are used, method confirmation and verification must be carried out in accordance with the provisions of GB/T 27417. In addition, the detection limit, accuracy, and precision should meet the requirements for groundwater testing.

4. Monitoring network construction

One of the goals of this project was to have a comprehensive understanding of the groundwater pollution in the counties and districts under the jurisdiction of Changde City. Another goal is to form a more unified and dense monitoring network with the existing five national-level well resources in Changde City.

The five existing well resources in Changde City are groundwater pollution tracking and monitoring wells, groundwater-type drinking water wells, soil pollution monitoring wells, groundwater environmental status monitoring wells, and pollution source groundwater quality monitoring wells[8]. In order to save national funds as much as possible and at the same time ensure the accuracy of groundwater pollution trend prediction, the existing data of five types of wells were collected and sorted out, and the available well

points were surveyed and analyzed on site. After unified numbering, selective sampling and testing were carried out according to the regional distribution. Through actual field investigation, there were 20 monitoring wells for groundwater quality in Changde City, all of which are national-level monitoring points, with one well and one pipe, with automatic monitoring technology. Therefore, while building 18 new monitoring wells for groundwater quality at pollution sources, the existing monitoring wells should also be repaired and maintained to ensure that a unified monitoring network can be formed after the project is completed.

The newly built upgraded monitoring wells are mainly designed for key industrial enterprises, polluted irrigation areas, and informal landfills near drinking water sources, so as to ensure the safety of drinking groundwater and improve the layout of groundwater monitoring networks. According to the monitoring point layout principles in the "Guidelines for Investigation and Evaluation of Groundwater Environmental Conditions" (2019), there are 7 monitoring points in each informal landfill block, industrial enterprise, general monitoring point, and agricultural area with reclaimed water. A total of 124 upgraded monitoring wells would be built through this project. The site selection of the 18 monitoring wells would also based on the existing 20 monitoring wells, that is, the original monitoring network, which will be in large and medium-sized industrial parks and informal landfills near groundwater drinking water sources. A total of 9 plots without groundwater monitoring wells were selected, and together with the original 20 monitoring wells, a relatively complete groundwater environment monitoring network that span across different areas, pollution sources, and drinking water sources was formed.

In addition to the construction of the monitoring network, an online monitoring platform was also built to further classify and analyze data[9] that is obtained through groundwater monitoring. The data is first uploaded to the monitoring platform, the water quality information of well points in the groundwater monitoring network are then recorded and updated. In this way, the groundwater quality can be understood clearly and intuitively in a timely manner. The monitoring platform can be used to display and analyze Changde City overall groundwater status. A new early warning interface will be developed in the monitoring platform in the future. By referring to the five types of groundwater quality requirements in the "Groundwater Quality Standard" (GB/T 14848-2017), the thresholds for each monitoring factor will be set. When the groundwater quality reaches a certain concentration, an early warning will be issued to report the abnormal situation, and corresponding countermeasures will be taken.

5. Conclusion

The successful implementation of this project yields the following suggestions and prospects for the development of the national groundwater monitoring network:

(1) During the drilling stage of groundwater projects, a more reliable and accurate judgment should have been made on the pipe material and pipe diameter to ensure the smooth progress of the construction.

(2) The project has improved the coverage groundwater networks in urban and rural areas. Through this project, new automatic monitoring wells were built, and the old and damaged monitoring wells in some areas were repaired, the outdated testing equipment was updated, and the original testing data in the area were sorted out and compared with the latest testing data. Comparing the data is beneficial to the overall management of groundwater in this area[10].

(3) The "Regulations on Groundwater Management" was passed at the 149th executive meeting of the State Council on September 15, 2021, and was officially promulgated on November 9, 2021 in Order No. 748 of the State Council of the People's Republic of China. The regulations clearly stipulate that environmental department of the State Council is responsible for the supervision and management of groundwater pollution prevention and control nationwide. Besides, it is also stated that the local

governments are responsible for the management of groundwater within their administrative regions, and relevant environmental departments are responsible for groundwater inspection, monitoring and other related work within their administrative regions. It can be seen that in the future, all provinces and cities across the country will fully develop and expand the construction of groundwater monitoring networks. This paper was written in hopes of providing valuable reference for similar projects in the future.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Sun W, Wang H, 2019, Research on Problems and Countermeasures in the Construction of Groundwater Monitoring Information System. Groundwater, 2019(5): 35-37.

[2] Yang L, Liang C, Li H, 2019, The Current Situation and Thinking of the Construction of Groundwater Monitoring Station Network in Guangxi. Water Resources Development and Management, 2019(6): 31-35.

[3] Li Q, Zhang P, 2019, Analysis on the Current Situation of Groundwater Resources in Shaanxi Province and Countermeasures for Protection and Management. Groundwater, 2019(5): 42-44.

[4] Hu Y, 2016, Thoughts on the Construction of Three-Level Groundwater Monitoring Station Network in Shandong Province. Shandong Land and Resources, 32 (12): 62-64.

[5] Yang P, Li Y, Wu G, 2019, Analysis and Prospect of Groundwater Monitoring Status in Shandong Province. Shandong Land and Resources, 35(1): 78-83.

[6] Yang R, Zheng C, Xia Y, 2020, Hunan: Analysis of the Status Quo of Groundwater Monitoring and Countermeasures. Regional Governance, 2020(5): 24-26.

[7] Yang Q, 2019, Influencing Factors and Control Measures of Environmental Monitoring Site Sampling Quality. Environment and Development, 31(10): 133-134.

[8] Ding Z, 2020, Application of R Software in Groundwater Environmental Quality Assessment. Environmental Protection and Circular Economy, 40(11): 4.

[9] Dong Z, Huang Y, 2002, A Review of Groundwater Dynamic Prediction Models. Western Exploration Engineering, 14 (4): 36-39.

[10] Liu J, Yang Z, Liu N, 2020, Reflections on the Capacity Building of Groundwater Environment Monitoring During the "14th Five-Year Plan" Period. Environment and Development, 32(5): 157-159.

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