

Study on Groundwater Environment Monitoring in Tailing Pond Area

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ABSTRACT

Luanchuan is surrounded by mountains, most of the area belongs to the mountain terrain, there are more metal mining areas, retained many large and small tailings ponds. The mining area is one of the seven major sources of groundwater pollution, that is, the tailings reservoir area has the risk of groundwater pollution. At present, the groundwater environment is investigated and evaluated, mainly the design and implementation of the groundwater environment monitoring well in the tailings reservoir area. Firstly, four monitoring Wells are built in the tailings pond. Monitoring well construction includes drilling core, reaming, pipe filling gravel, water sealing and well washing; Finally, a pumping test was carried out to determine the groundwater recharge and aquifer richness in the tailings reservoir area. The unit water inflow q of the aquifer in the area is $0.67\text{L/s}\cdot\text{m}$. After the completion of the monitoring well construction, it is determined whether the groundwater environment in the study area is polluted based on the experimental analysis. Once the water around the tailings pond is polluted, it is very likely to affect the drinking water source of the downstream villages, and the residents will seriously endanger their health after drinking.

KEYWORDS

Tailings reservoir; Groundwater pollution; Groundwater environment monitoring; Pumping test.

1. INTRODUCTION

Foreign groundwater environmental monitoring dates back to the 1970s and 1980s. In the middle of the 20th century, the United States began to set up groundwater data storage and retrieval systems, and further optimized the underground water quality observation network in the 1970s. Then in the 1980s, the United States officially set up the underground water quality monitoring network design working committee; In the 1990s, Timothy et al., of the US Regional Survey Bureau, used statistical methods to study the quantity optimization of groundwater quality observation networks ^[1]. The development of society and economy has led to the development and utilization of groundwater in our country, and the monitoring of groundwater environment has also gradually developed. After the founding of New China, China's groundwater environmental monitoring has experienced the following stages of development. Comprehensive initial stage: After the founding of New China, the water conservancy department initially carried out systematic groundwater monitoring in the Yellow River Irrigation Area of Ningxia, the four major Guanzhong irrigation areas (Jing, Wei, Jiao and Luo), the Shengli Canal Irrigation Area of Henan Province, and Anhui, Jiangsu, Hubei and Jiangxi provinces, and gradually developed it ^[2]. Rapid development stage: from the 1970s to the 1980s, the groundwater monitoring well network in northern China was initially formed. At the beginning, only water level (buried depth) was monitored, and at this stage, it has been transformed into multi-factor monitoring, including water level, water temperature, water quantity, water quality, etc. ^[3-4]. At the same time, the rapid development of groundwater monitoring has led to the occurrence of unreasonable exploitation such as groundwater overdraw and ground subsidence. Active

exploration stage: In the 1990s, due to insufficient funding, the coverage area of the monitoring network in some areas was once shrinking [5-8]. In addition, due to our country's rapid economic development at this stage, the rapid growth of ground water exploitation led to more and more serious unreasonable development of ground water, which seriously threatened the sustainable utilization of ground water resources and the ecological environment, in order to avoid the continuous deterioration of ground water environment, Various localities began to study and explore groundwater monitoring, management and research based on the actual situation [9]. Steady improvement stage: Since the 21st century, people have gradually realized the importance of groundwater and paid more and more attention to groundwater environment monitoring, and groundwater monitoring has entered a stage of steady improvement [10]. It is mainly manifested in the following aspects: the monitoring network in key areas should be treated with priority, and the density of groundwater monitoring station network should be improved by strengthening optimization. Meanwhile, advanced equipment has improved the means of groundwater information collection and transmission [11]. With the increase in the number of tailings ponds, dam break and leakage of tailings occur from time to time. Once an accident occurs, metal ions in tailings will cause pollution to surface water and groundwater, thus posing a threat to the health of nearby residents [12-13]. Therefore, it is urgent to investigate and evaluate the groundwater environmental quality in the Sanding ditch tailings pond area. Mainly through the design and construction of monitoring Wells in Sandagou tailings pond, and then analyze the water pollution situation, so that nearby residents can drink water at ease. Therefore, it is necessary to monitor the groundwater environment in the Sanding ditch tailings reservoir area..

2. GROUNDWATER MONITORING WELL CONSTRUCTION SCHEME

2.1. Monitoring well design scheme

Groundwater monitoring work is mainly suitable for submersible aquifers, the drilling depth should reveal the formation, but can not penetrate the shallow groundwater insulation floor; General monitoring well design depth should be less than the lowest water level in recent ten years 5m; If the groundwater level data in recent ten years is incomplete, the preliminary design is 50m based on groundwater dynamic amplitude, precipitation design and pumping test depth reduction under the condition of known water level. In the field work, it is adjusted and optimized according to the actual stratum and underground water level buried depth. (Pore water: final hole: silt 3 ~ 5m; 20%, not more than 120m; Diving 120m upstream and downstream no water will not play)

According to the general situation of the study area and previous data, the groundwater level of the fractured aquifer that belongs to the study area is unstable. Combined with the preliminary exploration data, the soil layer dug during the construction of the tailings pond is covered in this area, resulting in the submersible aquifer in this area generally covered at 15-30m, so the well depth can be roughly designed at 40m. However, the final hole depth should be determined by combining small hole coring and geophysical exploration.

2.2. Construction method

(1) Drill the core into the hole

- ① The rotary positive circulation drilling method is adopted, and the drilling is full hole coring.
- ② The weak formation is drilled with steel wire bit and valve bit to improve the core recovery rate.
- ③ In the drilling construction, in order to reduce the loss of well fluid, casing wall protection drilling process can be selected.
- ④ The hole inclination is not more than 1°/100m.

(2) Simple hydrological observation

In the process of monitoring well construction, it is necessary to carry out simple pumping hydrology observation and carry out a single hole steady flow pumping test with one drop. Submersible pump is selected for pump pumping, flow monitoring is measured by triangular weir, and electronic level meter is used to measure water level drop.

(3) Drain and change the pulp

After drilling, drain holes and change pulp according to the specification.

(4) geophysical logging

Geophysical logging should be carried out in time after drainage and slurry change, including apparent resistivity, apparent resistivity gradient, natural potential and well inclination. In order to improve the accuracy of formation survey data, geophysical logging should be carried out before well construction.

(5) Well pipe installation

Electrical logging should be performed before the well pipe installation. According to the electrical logging data, the formation results determined by the rock core taken in this well, the comprehensive test hole soil sample analysis results, the formation was accurately divided, the location of the filter pipe was determined, and the monitoring well structure in the single well design was corrected (including the length and the lower position of the wall pipe, filter pipe and sedimentation pipe, etc.).

The well pipe shall be connected by threaded butt joint. Adhesive and welding shall not be used.

(6) Gravel filling and water sealing

Fill gravel in accordance with construction specifications, fill gravel to the expected depth and measurement is correct, clay ball or cement water seal.

Gravel material should be selected with hard lithology, high density and good roundness quartz gravel, avoid the use of easy rock and iron-manganese containing gravel and flake or multi-angular gravel, to reduce the wear of gravel to the well pipe. The filter material is quartz sand with a diameter of 2 ~ 4mm, and the gravel should be cleaned with water or steam.

(7) Well washing

The pump is used to pump and wash the well, and the amount of water pumped generally reaches 3-5 times the volume of the well, and the well is washed after the water is cleaned and cleaned.

3. GROUNDWATER ENVIRONMENT MONITORING

3.1. Monitoring well construction

3.1.1. Borehole coring

Drilling core, low speed drilling process, as far as possible to ensure the integrity of the core; The cores taken are coded sequentially, and the coding process is shown in Figure 1. It can be seen from the general situation of the study area that the phreatic aquifer in the area where Sanding Gou belongs is mainly fissure aquifer, which belongs to bedrock fissure aquifer. Moreover, during the construction of the tailings reservoir, a large amount of Quaternary loess is covered on the phreatic aquifer, resulting in 5-15m loess above the phreatic aquifer. During the drilling process, it can be seen that the thickness of the aquifer in this area is generally 17-30m. Therefore, the monitoring hole depth in this area is 35-50m, and the final hole depth of the monitoring well is determined based on the drilling of the core. The monitoring borehole depth and water level buried depth are shown in Table 1.



Figure 1. Core catalog

Table 1. Monitoring the final hole depth and water level buried depth

Hole number	Latitude	Longitude	Well depth	buried depth
ZK01	33°48'27"	111°26'29"	49.68	2.27
ZK02	33°48'42"	111°25'57"	37.07	6.36
ZK05	33°48'35"	111°26'26"	41.96	4.14
ZK07	33°48'27"	111°26'32"	40.10	4.92

3.1.2. Reaming and gravel filling

According to the pre-reaming design, the hole diameter after reaming is 350mm and the hole bottom diameter is 200mm. After the location of monitoring well points was completed, the construction of monitoring points began. During the process of drilling and coring, it was found that the aquifer was granite with a large number of cracks, the rock layer had multiple groups of cracks, and the rock was broken by itself, rather than by machinery. The granite rock was hard and highly drillable, so water drilling was selected.

The composition of groundwater near the tailings pond is complex. In order to prevent the underground water from corroding the metal well pipe and affecting the subsequent test and sampling, PVC-U material is selected for the well pipe to reduce the pollution caused by the external environment to the groundwater composition. Quartz sand with a diameter of (2-4) mm is selected as the filler, bentonite powder is selected as the sealing layer, and quartz sand and bentonite powder are filled at a suitable distance according to the rock layer. Generally, quartz sand is filled at 0.6m above the aquifer until the bottom of the well, and the above part is filled with bentonite powder to achieve the effect of sealing the well. However, bentonite powder should not be filled too much, otherwise it will increase the difficulty of washing the well.

3.1.3. Sealing the water and sealing the well

Bentonite powder is used to seal the well. When the bentonite powder is put into the annular gap, the speed should be uniform and slow to prevent the bentonite powder from flying around and causing pollution to the environment.

3.1.4. Well flushing

Before the pumping test, the well should be washed first. The pump should be used to wash the well. After the well washing, the water quality tester is used to measure the well water, and the turbidity is less than or equal to 10NTU. However, the standard solution needs to be prepared when the water quality tester is used, and the configuration requirements of zero standard solution are strict, which is difficult to achieve on site. When the final selection of pumping water is 3 to 5 times the volume of water in the well, the well washing is ended.

3.2. Pumping test

It can be seen from the general situation of the study area that the aquifer of the tailings reservoir is all fractured granite, and the pumping test of monitoring well ZK01 is carried out to determine the water richness of the aquifer.

3.2.1. Water level

The static water level is measured by an electronic water level gauge before the pumping test. It can be seen that the static water level of monitoring well ZK01 is 3.05m. After measuring the static water level, start to lower the submersible pump, and increase the water level of the triangular weir box to the triangular entrance. When everything is ready, the flow rate is adjusted to 0.61m³ of the test pumping test while opening the switch, according to the time interval of 1, 1, 1, 1, 2, 2, 2, 5, 5, 5, 10, 10, 20, 20, 20. After this, observe once every 30 minutes until the water level is stable. After the water level is stable, turn off the submersible pump, and immediately start the recovery water level test, the time interval is 1, 1, 1, 1, 2, 2, 2, 5, 5, 5, 5, 10, 10, 20, 20, 20, and then observe once every 30min, and stop the test when the recovery water level is lower than 2cm/30min.

3.2.2. Data analysis

According to the data obtained from the pumping test, draw a depth-flow-time diagram, as shown in Figure 2.

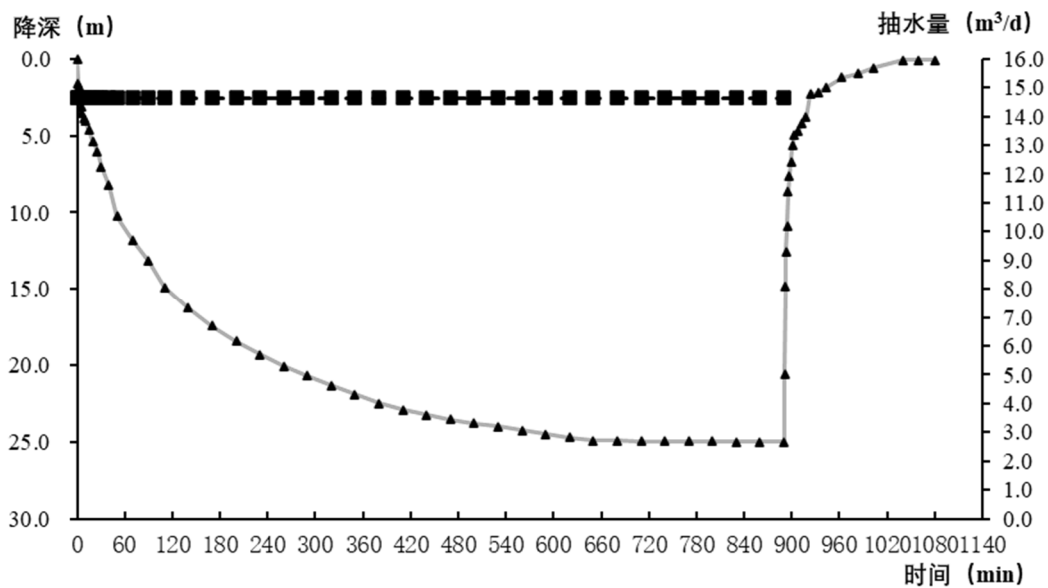


Figure 2. ZK01 borehole pumping test depth-time curve

Combined with the pumping test data, the calculation formula is as follows:

$$(2H_0 - s_w)s_w = \frac{Q}{\pi K} \ln \frac{R}{r_w} \quad (1)$$

$$R = 2s_w \sqrt{HK} \quad (2)$$

Where: Q - water inflow, m³/d;

R - aquifer influence radius, m;

H₀ - the thickness of the water-bearing part of the aquifer in its natural state, m;

H - the thickness of the water-bearing part of the aquifer under pumping state, m;

r_w - radius of pumping hole, m;

s_w - aquifer drawdown, m;

K - aquifer permeability coefficient, m/d.

It can be seen that the permeability coefficient K of the aquifer in the downstream area of the Sandagou tailings pond is 0.0347m/d, and the influence radius R is 45.30m, as shown in Table 2.

Table 2. List of depth drop and permeability coefficient of monitoring well

Hole number	drawdown s (m)	quantity of flow Q (m ³ /d)	Pumping hole radius r_w (m)	radius of influence R (m)	permeability coefficient K (m/d)
ZK01	25.00	14.64	0.07	45.3	0.0347

The ratio of the water inflow Q to the drawdown of the water level is the unit water inflow q, and it is easy to know that the unit water inflow q is 0.67L/s·m. Monitoring borehole diameter is non-standard borehole diameter, which needs to be converted and then compared with water richness, as shown in Table 3.

Table 3. Water-rich grade standards of aquifers

specific yield L/s·m	q<0.1	0.1<q≤1.0	1.0<q≤5.0	q>5.0
transmissibility	weak	medium	powerful	pole-strength

Note: To evaluate the water richness of the aquifer, the unit water inflow of the borehole is determined by the caliber of 91mm and the depth of the pumped water level is 10m. If the caliber and depth are not consistent with the above, the water richness should be converted and compared.

4. CONCLUSION

The following conclusions can be drawn through the design and implementation of the underground water environment monitoring well of sandagou tailing pond.

(1) According to the topography and geomorphology of the on-site exploration tailings pond, it can be seen that the left side of the tailings pond is a steep mountain peak that cannot be constructed for monitoring Wells. In fact, four groundwater environment monitoring Wells are constructed, namely, the upstream monitoring well ZK02, the right monitoring well ZK05, and the downstream monitoring Wells ZK01 and ZK07.

(2) In the construction of monitoring Wells, according to the core taking, it can be seen that 8 ~ 15m of quaternary mixed fill is overlying the submersible aquifer in the reservoir area, which is mainly caused by the accumulation of excavated soil around the tailings reservoir during the construction of the tailings reservoir, resulting in the thickening of the overlying soil layer; The bedrock is mainly granite, with a rough thickness of 15 ~ 30m. Because of the severe tectonic structure in this area, the granite has many cracks, which provides space for groundwater storage. That is, the aquifer in the area where the sandagou tailing reservoir is located is the bedrock fissure aquifer.

(3) According to the pumping test and recovery test, it can be seen that the water level in the region drops slowly during pumping and the groundwater level recovers quickly after the pumping is stopped. It can be seen that the groundwater recharge in the region is abundant and the water volume is large.

According to the test data, the unit water inflow q of the phreatic aquifer in this area is $0.67\text{L/s}\cdot\text{m}$. After conversion, it is easy to know that the unit water inflow q of the phreatic aquifer in the area of the Sandaogou tailings reservoir after conversion is $0.246\text{L/s}\cdot\text{m}$. According to the aquifer richness grade standard, the phreatic aquifer in this area belongs to the medium water-rich aquifer.

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