Confined water quality analysis and assessment of water source in Huan County, Qingyang city

Aiping Hu1,2, Yang Yang1,2* and Wanfeng Liu1,2

1 School of Civil Engineering, Longdong University, Qingyang, Gansu, 745000, China
2 Provincial Key Laboratory of Loess Engineering Properties and Application in Gansu Province Universities, Qingyang, Gansu, 745000, China
*Corresponding author’s e-mail: yy2513655687@qq.com

Abstract: To understand the quality of confined water in Huan County, Qingyang City and explore whether the water can be directly used as drinking water, this paper carried out the single component evaluation and comprehensive evaluation according to the national standard Sanitary Standard for Drinking Water (GB5749—2006) and Quality Standard for Ground Water (GB/T14848—2017). The result shows that the turbidity, total hardness, total dissolved solids, sulfate, chloride, fluoride and total σ radioactivity of in the single group of the confined water in Huan County, Qingyang City, cannot reach the national standard. In conclusion, based on the water quality analysis report and classification standard of the groundwater quality, the confined water quality of the water source in Huan County is poor, which cannot be directly used as the drinking water.

1. Background

Huan County is located in the east of the Gansu Province and the northwest of Qingyang City, whose north latitude is 36°1'-37°9' and eastern longitude is 106°21'-107°44'. Close to Huachi Country in Ganshu Province and Dingbian County in Shanxi Province in the east, Huan County meets Qingcheng County and Zhenyuan County of Ganshu Province in the south, Yuanzhou district in Ningxia Guyuan and Tongxin County in the west, and Yanchi county, Ningxia in the north. With 124km in the east-west width and 127km in the north-south length, the Huan County covers the total area of 9236 square kilometers [1]. The geomorphology of Huan County belongs to hilly areas of the loess plateau, 90% of it is covered by loess and its thickness of soil layer is between 60 m and 240 m. The landscape in Huan County mainly consists of mountain ridge beam, hilly, Chuan road and broken plateau. It belongs to temperate continental monsoon climate [1]. The urban area of Huan County adopts two water supply systems, including high area water supply system and low area water supply system. The main source of water supply comes from the Yellow River water of Zhangnanwan Reservoir, which is one part of the Huanxian Yellow River Project. The water storage of Zhangnanwan Reservoir is $70 \times 10^4 m^3$, maximum annual water supply is $200 \times 10^4 m^3$ and it is transferred three times a year. The alternate source of water supply in the county is Miaoergou spring water and confined water source of the county. As the irreplaceable natural resources, water resource plays an important part in economic development and the improvement of people's living standards [2-7]. The analysis and assessment of the confined water quality in this area provide the reference for improving the utilization efficiency of groundwater in this area and plays a significance role in the sustainable development of local economy.
and society.

Figure 1. Water source of Zhangnanwan reservoir in Huan County

Figure 2. Image of water source in Zhangnanwan reservoir

2. Current situation of confined water reserve water source

2.1. Geographical location and topography

Huan County is located in the favorable mining area around the river valley on the northwest side of the county town. The NW side of water source reaches from Gudaoban away from fifteen miles and the southeast side reaches the Hongxing village. Besides, Huan County is located in 36°34′10″～36°37′23″ north latitude and 107°15′05″～107°17′53″ east longitude. The east-west length of this county is about 6km, the width is about 1km, and the valley area is 6 km².

The geomorphic type of this water source is cutting and deposition valley and loess ridge hill. The width of the valley is about 1km and the floodplain, class I terrace, class II terrace, class III terrace and class IV terrace are developed on both sides of the autonomous riverbed in turn. The class I terrace is generally developed on the concave bank of Huanjiang River and is discontinuously distributed. Its step surface is 3~5m higher than the river bed. The class II terrace in the area is more developed with flat and open surface, which is slightly inclined to the main channel. Its slope is 2%, and the leading edge height difference is 2～3m. With strongly eroded surface, grade III terrace is developed in the piedmont and covered with Malan loess on its surface. Grade IV terrace is continuously distributed in front of the mountains on both sides of the valley and the terrace is covered with slope alluvial deposits. The gullies are more developed in the loess hilly area on both sides of the valley and there are loess beams and hilly loess hills between the two sides of the valley. The bank slope on both sides of the gully is relatively steep, the lower part of the slope is steep and straight, and the top of the loess hilly is round [8].

2.2. Stratum lithology

Expose strata of water source is described from the old to the news:

(1) Zhidan group of the Cretaceous (K₁z)

Huanhe group (K₁z₄): The upper part of the Huanhe group is arenaceous shale, grayish yellow and cinerous, whose top is weathered strongly. Some areas in the upper part are muddy and their thickness is about 15m. With the thickness of about 50m, the low lithology of Huanhe group is argillaceous siltstone and sand-shale stone, whose main element is argillaceous sand shale and muddy calcareous cement. The lower formation lithology is cinerous arenaceous shale, whose structure is dense and fissures are not developed. This layer is free of water and its thickness is about 8m. The low stratigraphy of Huanhe group is purple and purplish red siltstone, which has a good aquifer with the thickness of about 9m. The low stratum lithology of Huanhe group is argillaceous sand shale with fine sand layer, which is interbedded in fine sandstone, purplish red and purplish brown. The fine sand
layer and fine sand strata there are good aquifers and their thickness is more than 100m.

(2) Pliocene of neogene (N2)

With little exposure, only the sporadic exposes in the valley of Huanjiang River. The lithology of this group is brick red clay and its thickness is about 20m, which is generally less than 10m. This group is not integrated with the strata of the Lower Cretaceous Zidan group.

(3) Quaternary (Q)

The area is widely distributed and the main cause of formation is wind accumulation, followed by alluvium and alluvium accumulation, which almost covers the whole area. The cause of the formation in this area is diverse and well developed. Its strata includes the Wencheng loess of the Lower Pleistocene, the Lishi loess of the middle Pleistocene, the Malan loess of the upper Pleistocene and the alluvial layer of the Holocene.

(4) Hydrogeology

The water source aquifer of confined water in the county is Huanhe group strata of Zhidan group in cretaceous and the water type of groundwater is inter-layer confined water. The lithology of aquifer mainly includes sandy shale, argillaceous siltstone, interbedding of sand shale, silty fine sandstone and argillaceous sand shale with fine sand layer. Based on the exposure of hydrogeological drilling around the aquifer, the average thickness of aquifer is 102.69m. On the basis of the investigation, the strata are exposed at the bed of Huanjiang River. The buried depth of the roof in the valley is 3~10m and that in the gully region is 30~180m [9-10].

According to hydrogeological survey data, the depth to water table of confined water of Huanhe group in the valley is less than 30m and the buried depth of hilly is more than 30m. The flow of groundwater is mainly from the southwest to the south. The underground hydraulic gradient is 0.002~0.01 and it increases from north to south. The groundwater of Huanghe group in the water source is mainly recharged by lateral runoff and the entering boundary is the northeast boundary. The flow direction of the northwest boundary is the same as that of groundwater, which is the impervious boundary. The southwest boundary and southeast boundary are the outer boundary [9-10].

2.3. Characteristics of water chemistry

![Figure 3. Geological map of water source of confined water in Huan county](#)
Based on the analysis report of water quality of Huanhe group in the water source, the main water type of groundwater hydro chemistry is \( \text{SO}_4^{2-} \)-Na\(^+\) and \( \text{SO}_4^{2-} \)-Cl\(^-\)-Na\(^+\) (as shown in Figure 3) and the salinity is 2.51～4.62g/L. The chemical graph of water source of confined water in Huan county is shown in Figure 4.

### 3. Analysis and evaluation of water quality

#### 3.1. Evaluation methods and standard

The evaluation of the single items of the drinking water quality was finished based on the national standard Sanitary Standard for Drinking Water (GB5749—2006) and the comprehensive assessment was completed according to Quality Standard for Ground Water (GB/T14848—2017).

#### 3.2. Assessment of drinking water quality

(1) Evaluation of single items

Based on the water quality analysis results and Drinking Water Sanitary Standard, 26 factors, including the sensory trait index, general chemical index, toxicological index, radioactivity and chromaticity, naked eye visible substance, total hardness and volatile phenols, were selected to evaluate the single component, as shown in Table 1. In those 26 factors, the turbidity, total hardness, total dissolved solids, sulfate, chloride, fluoride and total radioactivity cannot reach the national standard.

(2) Comprehensive assessment

According to the water quality analysis report and classification standard of groundwater quality, 24 chemical indexes, such as chromaticity, bromine and taste, turbidity, naked eye visible, PH value, total hardness, soluble total solid, sulfate, chloride, iron, permanganic acid index, nitrate, nitrite, ammonia nitrogen, fluoride, were selected as evaluation factors. The comprehensive assessment of underground water was carried out and its evaluation results were shown in Table 1. The confined water quality of the water source in Huan County is poor, which cannot be directly used as the drinking water.

| Table 1. Evaluation of drinking water quality of confined water source in town |
|-------------------------------|-------------|-------------|-------------|-------------|
| Evaluation projects          | National standard | Confined water | Category | HX06 Category |
| -----------------------------|-----------------|---------------|-----------|---------------|

---

Figure 4. Chemical graph of water source of confined water in Huan county
Evaluation projects | National standard | Confined water | Category | HX06 | Category
---|---|---|---|---|---
**Sensory Character Indicators**
Colour (Degree) | ≤15 | 15 | III |
Bromine Harmony | - | - | I |
Turbidity | ≤3 | 5 | IV |
Particles visible to naked eyes | - | - | I |
PH | 6.5-8.5 | 7.85 | II |
Total hardness (CaCO₃, mg/L) | ≤450 | 814.65 | V |
Total soluble solids (mg/L) | ≤1000 | 3478 | V |
**General chemical index**
Sulfate (mg/L) | ≤250 | 1766.5 | V |
Chloride (mg/L) | ≤250 | 465.1 | V |
Fe (mg/L) | ≤0.3 | 0.0047 | I |
Mn (mg/L) | ≤0.1 | <0.00006 | I |
Cu (mg/L) | ≤1.0 | 0.00776 | I |
Zn (mg/L) | ≤1.0 | <0.0008 | I |
Volatile phenols (mg/L) | ≤0.002 | <0.002 | III |
Nitrate (mg/L) | ≤20 | 4.26 | II |
Nitrite (mg/L) | ≤0.02 | <0.001 | I |
NH₄ (mg/L) | ≤0.2 | <0.02 | I |
Fluoride(mg/L) | ≤1.0 | 1.39 | IV |
Iodide(mg/L) | ≤0.2 | 0.0109 | I |
Cyanide(mg/L) | ≤0.05 | <0.002 | II |
As (mg/L) | ≤0.05 | <0.001 | I |
Cd (mg/L) | ≤0.01 | <0.00006 | I |
Cr⁷⁺ (mg/L) | ≤0.05 | <0.004 | I |
Pb (mg/L) | ≤0.05 | <0.00007 | I |
**Radioactive indicators**
Total σ Radioactivity(Bq/L) | ≤0.1 | 0.6 | IV |
Total β Radioactivity(Bq/L) | ≤1.0 | 0.26 | II |
F mean value | 2.54 | |
F value | 7.3 | |
Water quality grade | Extremely poor | |
Hydro-chemical types | SO₄²⁻—Na⁺ | |

4. Conclusions and suggestions
Based on the national standard Sanitary Standard for Drinking Water (GB5749—2006) and Quality Standard for Ground Water (GB/T14848—2017), the single component evaluation and comprehensive evaluation were carried out. The results show that the confined water of reserve water source is SO₄²⁻—Na⁺ water type and the comprehensive evaluation score of confined water is 7.3 points. The six indexes of the confined water in Huan County cannot reach the national standard. The turbidity degree of the single group belongs to IV type; the total hardness belongs to V type; the total dissolved solid belongs to V type; the sulfate belongs to V type; the chloride belongs to V type; the fluoride belongs to IV type and total σ radioactivity belongs to V type. In conclusion, according to the water quality analysis report and classification standard of the groundwater quality, the confined water quality of the water source in Huan County is poor. Consequently, it could not be directly used as the drinking water. It is suggested that the groundwater pollution and dynamic monitoring should be carried out for confined water source in Huan County. Therefore, the technical support for the development and protection of groundwater resources is provided, further deterioration of
groundwater quality is avoided and the safety of reserve confined water source is guaranteed.

Acknowledgment
(1) Project of 2019 Industry Green Low Carbon Transformation and Upgrading, Provincial Department of Industry and Information Technology, Gansu, China (GGLD-2019-055);
(2) Research Project of Universities, Provincial Department of Education, Gansu, China (2018B-054);
(3) Project of the 13th Five-Year Plan, Provincial Department of Leading Group for Educational Science Planning, Gansu, China (S 2019 GHB2065);
(4) Youth Science and Technology Innovation Project, Gansu, China (XYZK1709);
(5) Project of 2019 Industry Green Low Carbon Transformation and Upgrading, Provincial Department of Industry and Information Technology, Gansu, China (GGLD-2019-053);

References
[1] Xupeng Li. The status of rural microfinance loans and its influence on farmer’s income in Huanxian county, Gansu province[D]. Lanzhou University, 2017.
[2] Aiping HU, LIU Wanfeng, et al. Analysis and Evaluation of Water Resources for Urban Water Supply in Northwest China[J]. City and Town Water Supply, 2018(05): 66-71.
[3] Yang Yang, Aiping Hu. Supply-requirement Analysis and Regional Status Water Resource of Qingyang [J]. Journal of Irrigation and Drainage, 2018, 37(Supp. 1): 100-103.
[4] Qinglin Mu. Current Situation Analysis and Sustainable Development Countermeasure of Water Resources in Huanxian County[N]. Longdong Daily. 2006-06-15.
[5] Haolin Xin, Wanfeng Liu, et al. A Study on Sustainable Utilization of Water Resources in Qingyang City[J]. Journal of Longdong University, 2016, 27(5): 117-122.
[6] Yuan Wang, Lianxi Sheng, et al. Analysis of present situation of water resources and countermeasures for sustainable development in China[J]. Journal of Water Resources and Water Engineering, 2008(3): 10-14.
[7] Jun Xia, Jinliang Zhai, et al. Some reflections on the research and development of water resources in China[J]. Advances in Earth Science, 2011, 26(9): 905-915.
[8] Fuyun Guo. Groundwater Distribution Regulation and its Exploitation and Utilization Countermeasures and Study in Longdong Energy Base[J]. Groundwater, 2011, 33(5): 44-46.
[9] Fangwen Zheng. Analysis of Hydro geological Setting and Groundwater Resources Evaluation in Longdong Region[D]. Chang’ an university, 2009.
[10] Bin Li. Impact of Cretaceous Groundwater Occurrence Characteristics on Ecological Environment in Longdong Basin[J]. Resources Economization & Environmental Protection, 2015 (05): 170-170, 172.