Investigation on pollution sources of a Karst Underground River in southwest Guizhou

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Abstract: by means of karst hydrogeology investigation, pollution source investigation, water pollution status investigation, water quality sampling and detection, the water pollution of large karst underground river in Muerdong of southwest Guizhou Province was investigated and demonstrated. The analysis shows that: (1) the catchment area of groundwater unit in Muerdong-qingping River is about 270 km², and there are many karst pipelines in the area, and finally discharge at the exit of the underground river at the lowest discharge datum level in the area. (2) there are mainly four replenishment subsystems in the underground river, it is found that the karst water system of Dajiang and Tamping river is finally discharged through the Q4, Q5 and Q6 karst springs or the underground river of Muerdong River, and neither the spring water nor the underground river is polluted, the outcrops of Yangjiaba Karst water system and Bayan karst water system in Muerdong underground river are Q1, Q2 And K35. The spring water and groundwater in the cave are polluted (3) the main pollution of the underground river of Muerdong is from the excrement of livestock and poultry in DK farm in the karst water system of yangjiaba, which is discharged into the underground pipeline of the underground karst river through the falling water cave. The water source area of Muerdong underground river is located in the strong karst area, the geological environment is fragile, and the suitability of developing large-scale aquaculture industry is poor. The government needs to enhance the understanding and use for reference in attracting investment.

Keywords: Karst River; water pollution; Karst Water System; Pollution Source Investigation; Water Quality Inspection; livestock and poultry excrement

0 introduction

The southwest of China is the largest karst area in the world, with an area of about 5105 km² (Zhangmei, 2017). Karst Hidden River is one of the most important karst phenomena in karst area, and it is also an important water source for human production and life in southwest karst area. However, with the development of industry and agriculture, the intensification of human activities and the fragility of Karst Aquifer, karst groundwater is facing many threats such as water pollution and water resource depletion.

In recent years, more and more attention has been paid to the study of Karst River pollution. Lin Yongsheng and Pei Jianguo analyzed the groundwater quality and pollution sources of the underground river system in Mashan, Guangxi. Seven organic components were detected in the water samples, which were in good agreement with the groundwater pollution index (Gus), the main pollution sources are pesticides and fertilizers used in industry and farmland (Lin Yongsheng and Pei Jianguo, 2015). Zhangheng based on a pollution investigation project of an underground river in the southwest coal region of Guizhou, the methods of pollution source investigation and analysis include basic data collection, pollution correlation analysis, karst hydrogeological investigation, topographic analysis, pollution source investigation, water pollution status investigation, image analysis, geophysics exploration, water quality detection, connection test and pollution source.
demonstration (Zhangheng, 2016). Based on the analysis of a karst underground river system in Nanshan, Chongqing, Liao Yu indicated that the water body of the underground river system in Nanshan was polluted by fecal matter by the composition and characteristic parameters of the particulate steroids, and the excrement pollutants mainly come from the direct input of human excrement and the pollution of old human excrement (Liao Yu, 2017). This paper takes the investigation of the pollution source of the underground water system of a karst river in southwest Guizhou as an example, through the collection of basic data, karst hydrogeological survey, topographic analysis, pollution source investigation, water quality testing and other means of pollution source investigation. It is expected to provide experience for the investigation of underground river pollution in karst area.

1 Survey of pollution in survey area

In mid-november 2020, a karst underground river in southwest Guizhou (hereinafter referred to as Muerdong) suddenly polluted the water and caused the Qingping river water in the lower reaches to be seriously polluted. The Qingping river in the Muer area is a first-class protection area of drinking water source area. The population of the surrounding market town is about 30,000 people. The site contamination is shown in figure 1.

![Photo of water pollution at exit of Muer dong](image)

**Fig. 1** Photo of water pollution at exit of Muer dong

2 Basic geological conditions of the survey area

The survey area is located at the boundary between the Pu’an County twisting tectonic deformation area of the Guizhou Platform and the Wangmo northwest tectonic deformation area of the South Platform Depression in Guizhou, where the north-east tectonic deformation is dominant. The area to the Muerdong River as the boundary, can be divided into east and West two areas. The East area of Muerdong River is a non-soluble clastic rock area, the lithology is represented by the sandstone and mudstone of the Middle Triassic Bianyang formation (T₂b), and the west side is a soluble carbonate rock area, the lithology is represented by the thick massive Algal debris and Algal agglomerate limestone of the Middle Triassic Longtou formation (T₂l).

3 Methods of Investigation and analysis

3.1 Investigation of water pollution

According to on-the-spot investigation, six outcrops of the underground river are distributed in the area of 500m, the discharge in dry season is 200 ～ 250 l/s, the discharge in flood season is 5 ～ 10 m³/s, and two large-scale karst caves are developed in the surrounding area. From upstream to downstream, the springs are:

1. Spring Q1: located at the headwaters of the Qingping reach of the Muer Dongping River, the rock crevices under the Fort on the right bank of the river channel are exposed. The exposed elevation is 754 m, the water volume is about 10 ～15 L/s, the water body is turbid, the rocks at the outlet are obviously black, and there is the odor of livestock and poultry excrement.
(2) Spring Q2: located at the headwaters of the Qingping reach of the Dongqingping reach of the Muer River, the Rock crevices under the ridge of the farmland under a ditch on the right bank of the river are exposed. The exposed elevation is 754.3 m, the water quantity is about 15 ~ 20 L/s, the water body is turbid, the rock is obviously black, and there is the odor of animal excrement.

(3) Spring Q3: located at the headwaters of the Qingping reach of the Muer Dongqing River, the stone crevices under the road fort on the Left Bank of the river channel are exposed. The exposed elevation is 754m, the water quantity is about 10~15 L/s, the water body is limpid, there is no pollution trace in the outlet water.

(4) Spring Q4: located in the upper reaches of Qingping reach of Muer Dongdong, the spring is exposed in the stone crevices on the Left Bank of the river, and the stone slabs have been built at the exit for protection. The exposed elevation is 750m, the water quantity is about 50~ 60L/s, the water body is limpid, the water quality is good, and there is no pollution trace in the underground river.

(5) Spring water Q5: It is located in the ridge of the middle and Right Bank of a branch of the upper reaches of the Dongqingping reach of the Muer River. The exposed height is 750.5 m. the water quantity is about 40~50 L/s during the investigation period. The water body is clear and the water quality is good. There is no obvious pollution trace in the underground river.

(6) Spring Q6: located in the upper reaches of Qingping reach of the Dongmuer River, it is formed by many streams of spring water in stone crevices. The exposed elevation is 750 ~ 751 m, the water quantity is about 60 ~ 80 L/s, the water body is limpid, the water quality is good.

(7) Karst Cave K35: located in the southern side of Muerzhaizi, under a rock wall, exposed elevation about 770m, the Karst cave developed nearly east-west Longitudinal. Because of the deep groundwater in the cave, it is difficult to inspect during the survey period. The water body in the cave is muddy and smelly.

(8) Karst Cave K36: located in the West Side of Muerzhaizi road under the Rock Wall, exposed elevation about 756m, this karst cave vertical 60° ~80° down development. During the investigation period, because the water level in the cave is about 754m deep, there is no water flowing, the water quality is clear and there is no trace of pollution.

The distribution positions of spring water spots and karst caves are shown in Fig. 2.
3.2 Basic data collection

(1) Characteristics of pollutants and environmental conditions

From the attachment in the water, the pollution of the water body in the hole has the characteristics of pig manure pollution. The pollutant discharge time of fungus hole is long, the heavy pollution duration is about 15 days, after that the pollution degree gradually reduces, explained its pollutant discharge quantity is big. According to the preliminary investigation, there are many farms in the area of Muerdong Dark River, and the main types of the farms are pig and sheep. The investigation area belongs to Karst developing area, the soil layer is thin, the absorption capacity of the soil is poor, and there is the possibility of concentrated sewage discharge. According to the above characteristics, the pollution source of water body in Muerdong should be excreted from the surrounding farm and carried by the groundwater to the exit of the underground river. However, it is difficult to determine the breeding farm which is related to the water pollution of the karst underground river for a while, so detailed investigation is needed.

(2) Scope of investigation

According to the surface and groundwater runoff characteristics, the project area can be divided into 4 hydrogeological units. Muerdong-qingpinghe groundwater unit (unit I) is a carbonate rock development area with
a catchment area of about 270 km². Along the karst troughs, there are mainly Daijiang surface river, Ronglai surface river and Tamping surface river on the surface, the surface runoff is mainly discharged through karst depressions and falling water holes after entering the underground undercurrent section at the exit of the underground river in Muerdong, while the groundwater unit (Unit II) in Anlong County-zhaodi is a carbonate rock development area with a catchment area of about 200 km², the surface runoff mainly flows through the karst depression, the Cave of falling water into the underlying flow section and finally flows out in the form of karst spring in the south of the unit area Sifandong groundwater unit (Unit III) is a carbonate rock development area with a catchment area of about 260 km². The larger surface water body is mainly Bazi river, the surface runoff is mainly discharged in the form of karst spring at the east side of the unit area, where the groundwater unit (Unit IV) of Diantianhe is the distribution area of clastic rock, the catchment area is about 100 km², and the surface water and ground water in the area finally converge into the Datian River. Among the four hydrogeological units, the groundwater of Qingping River Muerdong is mainly influenced by Muerdong-qingping River groundwater unit (unit I).

Muerdong-qingping River Groundwater Unit (unit I) can be subdivided into east and west zones with Muerdong as the boundary. The East area is a clastic rock area and a non-soluble rock. According to its hydrogeological characteristics, it can not cause the pollution of the Karst River, so the area is not in the scope of investigation. Therefore, the scope of this investigation is narrowed down to the distribution area of carbonate rocks on the west side of Muerdong cave.

3.3 Topographic analysis

The survey area is located at the southeast edge of Yunnan-Guizhou Plateau, which is located in the slope zone of the transition from the hilly area of the Central Plains to the hilly area of the low mountains and hills of Guangxi in southwest Guizhou. The investigation area is a geomorphological unit of Karst Trough Valley, which is composed of several parallel karst troughs in nearly east-west direction. The elevation of Mountain Ridge is 1499–1590.6 m, the elevation of trough is 800–1300 m, the lowest point is Muerdong River, the elevation is about 750 m.

3.4 Karst hydrogeological survey

The survey area is located between the Nanpan River and Beipan River River Systems and on the side near Beipan River, where the water cycle alternates strongly due to the strong uplift of the neotectonics and the rapid cut-off of the rivers, the underground karst water system and karst cave system are well developed.

There are many hydrogeological units composed of open flow and volt flow in the investigation area. The entrance of Karst pipeline is scattered in the vertical sinkhole at the bottom of each karst depression, and the exit of underground river is finally formed in Muer cave. The underground river of Muerdong is the lowest discharge datum of groundwater in the survey area.

3.5 Source Investigation

According to the topographic features of karst troughs in the Muerdong hidden river recharge area, the investigation can be divided into 4 subsystems, as shown in Fig. 3. In this field investigation, the water quality in the open-flow section of the recharge area was investigated, and the water samples from the inlet and outlet of the open-flow evanescent current were examined and compared Investigation method of pollutant emission from aquaculture farm in karst depression and sinkhole area in the upper part of underground stream.
3.5.1 Dajiang karst water system

1) Ambient and water pollution in the open stream

The open flow section of the water system is mainly composed of two parts: The open flow on the north side is about 6 km, the catchment area is about 7 km$^2$, and the open flow enters the deep flow through the Dajiang Trough Valley near the Karst Depression in Lor Mee; the open flow on the south side is about 6 km, and the catchment area is about 11 km$^2$, through the ronglai Valley, the Karst Depression in the lower reaches of ronglai enters the volt current.

1) On-the-spot investigation: Through on-the-spot investigation, there is no any farm distribution in all the open flow section of the water system. Only in the concentrated place of the village to see local domestic sewage,
occasionally seen farm poultry excrement, very small, no obvious water pollution.

2) Water sample analysis: There are 2 water sample points in the open flow section of the region, the specific monitoring data are shown in Table 1. Through the water sample analysis, except for the suspended matter, all the factors of the monitoring points meet the Class III water quality standard in the environmental quality standard for surface water. It can be concluded that the water quality in the open flow section of the recharge-runoff area is good.

| Monitoring Point | The mouth of the Xiayulang sinkhole | The mouth of the ronglai sinkhole | Reference Range |
|------------------|-------------------------------------|----------------------------------|-----------------|
| Monitoring indicator | Measured value | Standard Index | Excess multiple | Measured value | Standard Index | Excess multiple |
| Turbidity (NTU) | 2.020 | 0.673 | NO | 2.599 | 0.866 | NO | 3* |
| PH | 8.38 | 0.69 | NO | 8.31 | 0.655 | NO | 6–9 |
| Permanganate (mg/L) | 1.21 | 0.403 | NO | 1.40 | 0.467 | NO | 3.0* |
| COD (mg/L) | 2 | 0 | NO | 2 | 0 | NO | 20 |
| BOD (mg/L) | 0.8 | 0.2 | NO | 0.7 | 0.175 | NO | 4 |
| Ammonia nitrogen (mg/L) | 0.030 | 0.03 | NO | ND | 0.0125 | NO | 1.0 |
| Total phosphorus (mg/L) | ND | 0.25 | NO | 0.016 | 0.08 | NO | 0.2 |
| Suspended matter (mg/L) | 47 | 1.88 | 0.88 | 38 | 1.52 | 0.52 | 25** |
| Fecal coliform (MUP/L) | 1.7×10³ | 0.17 | NO | 1.1×10³ | 0.11 | NO | 10000 |
| Chroma | 5 | 0.333 | NO | 5 | 0.333 | NO | 15** |

(2) Pollutant emission from farm in Karst Depression and falling water cave in the upper part of volt-current section

The open flow of the water system enters into the overcurrent at the karst depressions (W1=1067m, W2=1055m) in the south of Zhushadong and Namashi, respectively, and at the ronglai Haizi Karst Depressions (W5=1062.5m) in the south. Volts flow through the Tianjia Wan Depression (W4=975m), small copper sub-depression (W7=888.8m) and other string bead-shaped depression at the lower part of the karst pipeline system, from the Muer dong (H=750m) around the form of Karst Springs.

Through investigation, there is no breeding farm and no pollutant emission in karst depression and falling water cave distribution area in the upper part of the depression.

(3) Comparative analysis of water quality between volt inlet and auricularia hole outlet

In the process of water quality evaluation, the representative pollution factors such as permanganate index, Chemical oxygen demand, biochemical oxygen demand, ammonia nitrogen, total phosphorus and fecal coliform were selected for comparative analysis, then, the correlation between the quality of the volt inlet water and that of the outlet water of the Hidden River was judged.

For example, table 2 shows that the water quality in the region can meet the requirement of “surface water environmental quality standard III”. After entering the karst system, the water quality can be purified to some extent through the self-purification function of the ecosystem. The groundwater environment of Dajiang Karst water system is not polluted by aquaculture wastewater.

| Monitoring Point | The mouth of the Dajiang sinkhole | The mouth of the ronglai sinkhole | The mouth of the Xiayulang sinkhole | Q4 | Q6 |
|------------------|----------------------------------|----------------------------------|----------------------------------|-----|-----|
| Permanganate (mg/L) | 4.11 | 1.4 | 2 | 1.17 | 0.72 |
| COD (mg/L) | 13 | 2 | 2 | 7 | 1 |
| BOD (mg/L) | 3.8 | 0.7 | 0.8 | 0.5 | ND |
| Ammonia nitrogen (mg/L) | 0.168 | ND | 0.03 | ND | ND |
| Total phosphorus (mg/L) | 0.011 | 0.016 | ND | ND | 0.012 |
| Fecal coliform (MUP/L) | 1.7×10³ | 1.1×10³ | 1.7×10³ | 50 | 80 |
3.5.2 Tanping river karst water system

(1) Ambient and water pollution in the open stream

The open-flow section of the water system consists of two parts: the open-flow section on the north side is about 10 km long and the catchment area is about 20 km². The open-flow section on the south side is about 1.5 km long and the catchment area is about 3 km², through the Shipeng Valley in the lower reaches of Majiadong near the karst depression into the volt-current.

1) On-the-spot investigation: Through investigation and visit, there are 3 farms in the area of Open flow section of the water system, but all of them are abandoned pig farms. Through a comprehensive investigation, the two open-flow streams of the water system were relatively clear, and the farms in the open-flow area did not discharge wastewater to surface water.

2) Water Quality Analysis: There are 2 water sample in the area, which are the volt inlet of Tanpinghe power station depression and the volt inlet of stone bump. According to the analysis of water samples, all the factors of monitoring sites meet the Grade III water quality standard in the environmental quality standard for surface water. The results show that the water quality in the open flow section of the recharge runoff area is good.

(2) Pollutant emission from farm in Karst Depression and falling water cave in the upper part of volt-current section

The open flow of the water system enters into the overcurrent at the karst depressions (W8= 1056.8m) in the Haitian area on the north side and at the Majiadong karst depressions (h=1102.5m) on the south side. The volt flows through the karst pipeline system in the lower part of the beaded depression such as the broken house depression (w9=996.9m) and the qiujiaying depression (W10=880m) , and discharges in the form of karst spring from the Muer Cave (H=750m).

Through a comprehensive investigation, there are three karst depressions in the area of the north part of the water system, and no farm is found in the depressions. In the area of the southern fulv current, there are mainly the Shipeng depression, the Majiadong falling water cave and the Hemachong depression. There is a family farm in the area of volt current on the South side, which is now breeding 10 head. The faecal pollutants of the farm were not discharged into karst pipes, but the fertilizer used for farmland and orchard was dumped to the surface. To sum up, there is no pollutant discharged from large-scale farm to karst pipeline in the karst depression at the upper part of the volt-current section of the water system.

(3) Comparative analysis of water quality between volt inlet and auricularia hole outlet

According to Table 3, the water quality in the region can meet the requirement of “surface water environmental quality standard III”. After the region surface water enters the karst system, through the self-purification function of the ecosystem, the effluent water quality can be purified to some extent. The groundwater environment of Tanping River Karst water system is not polluted by aquaculture wastewater.

| Monitoring Point | The mouth of the Qingping river sinkhole | The mouth of the Shipeng sinkhole | Q4 | Q6 |
|------------------|----------------------------------------|----------------------------------|----|----|
| Permanganate (mg/L) | 1.42 | 1.58 | 1.17 | 0.72 |
| COD (mg/L) | 2 | 3 | 7 | 1 |
| BOD (mg/L) | 0.7 | 1.1 | 0.5 | ND |
| Ammonia nitrogen (mg/L) | 0.178 | 0.087 | ND | ND |
| Total phosphorus (mg/L) | ND | 0.012 | ND | 0.012 |
| Fecal coliform (MUP/L) | 8.0×10² | 2.2×10³ | 50 | 80 |

3.5.3 Yangjiaba karst water system

(1) Ambient and water pollution in the open stream

DK’s pig breeding farm is located at the junction of open current and volt current. The investigation period
was the dry period, and there was no obvious flow in the water system. Dk Breeding site outside the company saw two drainage channels through, investigation, the breeding site upstream channels have dried up, in the DK breeding site downstream redundant water point to see a small amount of surface water. According to the investigation, during the flood season, DK company breeding field outside the ditch water volume is larger, the flow often overflow the ditch, to the surrounding water hole into the underground karst channel.

1) On-the-spot investigation: As mentioned before, DK 2 # breeding farm is the breeding base for pigs of DK company. It raises 4000 piglets all the year round and has been continuously producing. According to the investigation, there are sewage treatment facilities in the site, and the treated sewage is used for greening and irrigation of surrounding farmland, but according to the investigation, the sewage treatment facilities are seldom used. And there are a number of vertical sinkholes around the field area located in the karst depression.

2)Water sample analysis: There is 1 water sample point in the open flow section of this area, which is the water seepage in the downstream of DK breeding ground. As table 4 shows, through the analysis of water samples, DK Breeding Stadium there is suspended matter, fecal coliform group exceeded the standard phenomenon.

Table 4 statistical table of monitoring data of Dajiang karst water system

| Monitoring indicator | W6 Rongrao Surface water | Reference Range |
|----------------------|-------------------------|----------------|
| Turbidity (NTU)      | ND                      | 3*             |
| PH                   | 5                       | 6–9            |
| Permanganate (mg/L)  | 1.71                    | 3.0*           |
| Chemical Oxygen Demand (mg/L) | 10 | 20 |
| BOD (mg/L)           | 1.2                     | 4              |
| Ammonia nitrogen (mg/L) | 0.062                  | 1.0            |
| Total phosphorus (mg/L) | 0.063                  | 0.2            |
| Suspended matter (mg/L) | 42                     | 25**           |
| Fecal coliform (MUP/L) | 2.6×10^4               | 10000          |
| Chroma               | 5                       | 15*            |

(2)Pollutant emission from farm in Karst Depression and falling water cave in the upper part of volt-current section

Overgrown-the ground in the Yangjiaba Trough Valley shows that the current gradually seeps into the ground near the DK 2 # breeding site, the karst pipeline system in the lower part of the Rongyue karst depression (W16=1235m), the Yangjiaba karst depression (K18 = 1021.5m, K36 = 1050m), the Chuandong karst depression (K7=989.5m) and the Yunchangyan karst depression (K24=880m) is integrated, after the groundwater converges with the karst water system of Biyan, Changchong and Longdongwan in the area of K35(H=780m) of Lianhe village, it turns southwest along the phase change zone and appears as karst spring (Q1, Q2) in the area of Muerdong River.

The karst is strong developed in the upper part of the volt-current section of the water system, and karst depressions and falling water holes are widely distributed. Among them, DK company 2 # breeding ground upstream ditch side see K14, K15 water hole, flood season period, the ground shows the flow through the ditch convergence from here into the ground. The dry season may also be used as the outlet of livestock wastewater. K36, K37 and K38 sinkholes are distributed in the lower reaches of the breeding pig farm of 1 # DK company. The dry season may also be used as the outlet of livestock wastewater.

1)The distribution of breeding farms: There are 5 breeding farms in the depression of rongyue -yangjiaba trough. Among them, DK company 1 # pig farm completely covered W19 Yangjiaba depression, covering an area of 213400m². Its breeding pig 2000 head, perennial production of unknown number of seedlings. As mentioned earlier, DK company 2 # breeding pig farm is located in W16 about the depression, the pig farm perennial
breeding 4000 piglets. 13 # Jiangjiancun sheep farm is located in W18 depression on the north side of Trough Valley. The sheep farm is not large-scale and is self-supported by villagers, with less than 20 sheep. 16 # farm is now abandoned near the Chuandong depression. 18 # Harbin pig farm is located in Fuha village on the north-west side of rongyue Depression (W14 depression). It currently raises about 30 pigs on a small scale.

2) Pollutant disposal: According to investigation, DK No. 1 breeding pig farm and DK No. 2 breeding pig farm belong to the large-scale Breeding Farm of DK company. According to the EIA report of the project, sewage treatment facilities were installed in both farms and the effluent was discharged after being treated to the required standard. The treated sewage is used for greening and irrigation of surrounding farmland and is strictly prohibited from being discharged into the underground funnel. But according to the survey, the sewage facilities are rarely used.

In a word, there are many pollutant sources in the karst depression in the upper part of the volt-current section of the water system. However, for the pollution source produced by the large-scale breeding farms in this area, there is the possibility of overflow to the surface to the karst pipeline after the treatment is not timely or the rainstorm is saturated, which cannot rule out the possibility of polluting the underground undercurrent.

3.5.4 Bayan karst water system

(1) Ambient and water pollution in the open stream

The underground karst pipelines of this water system are strongly developed. The surface water usually flows into the subsurface current through karst fissures and caves. The investigation period is a dry period, the water system did not show obvious outflow, most of the creek is dry. During the flood season, surface water often collects along low-lying areas and gullies, plunging into the ground in the sinkhole. During this period, the water pollution assessment of the open flow section was not made because the surface flow was not exposed and the water samples were not taken.

(2) Pollutant emission from farm in Karst Depression and falling water cave in the upper part of volt-current section

This water system mainly exists in the form of volt flow, after the surface water body plunges underground, through the Chang Chong karst depression (K25=1485m), the Bayan karst depression (K26=1143.1m), the Shuijingwan karst depression (K32=935m) or the Longdongwan karst depression (K29=968.1m), the Shuijingwan karst depression (K32=935m), the karst pipeline system in the lower part of the beaded depression is integrated, after the groundwater converges with the karst water system of Rongyue and Yangjiaba in the area of K35 (H=780m) of Lianhe village, it turns southwest along the phase change zone and emerges as karst spring (Q1, Q2) in the area of Muerdong River. In this area, the pollutant emission from the livestock farm in the Karst Depression in the upper part of volt current river was investigated.

1) The distribution of the Farms: After investigation, the Karst Depression area is distributed as follows: 4 # chicken farm, 14 # chicken farm, but have stopped breeding for many years, now abandoned.

2) Disposal of pollutants: According to the investigation, W32 depression site No. 3 was used as a dumping site for Chicken Excreta and stopped dumping after 2017, at present, there is a certain amount of black soil-like dried chicken feces in the bottom of the Karst depression.

To sum up, the water system is mainly karst pipeline of groundwater, and the waste farm and chicken excrement dumping field in the karst water system have little influence on groundwater pollution.

3.6 Pollution source demonstration

According to the above analysis, there are mainly four recharge systems in the underground river of Muerdong. According to the hydrogeological conditions and water quality analysis, dajiang karst water system and Tanping River Karst water system are finally discharged through Q4, Q5 And Q6 Karst Springs or underground rivers of Muerdong River, which are not polluted. The outlet points of Yangjiaba Karst water system and Biyan karst water system in Muerdong river are Q1 and Q2, and K35 in the karst cave. The spring water and
the groundwater in the karst cave are polluted, however, there is no large-scale farm distribution in the confluence area of Biyan karst water system, and there is no pollution source in the system. Therefore, the karst water system of Yangjiaba is the karst water system which causes the pollution of Muerdong River.

There are large pig farms in Yangjiaba karst water system in the main karst depressions of Rongyue and Yangjiaba. According to the investigation, there are about 4000 adult pigs in the pig breeding farm of DK company, the discharge amount of livestock wastewater and domestic sewage is about 100 m$^3$/d, the total number of adult pigs in the pig farm of DK company group is about 3400, the discharge amount of livestock wastewater and domestic sewage is about 85 m$^3$/d, and the livestock wastewater is mainly used for greening and surrounding agricultural irrigation after being treated, its emissions are high. There are sinkholes in the depressions, and it is inevitable that the animal excrement seeps into the underground karst pipe system and finally pollutes the groundwater. According to the analysis of the water samples at the open flow point near the No. 2 pig farm of the DK company, the Chemical oxygen demand index is seriously over the standard, while the test results of the sediment Q1 sampling in the riverbed at the source of the Muerdong hidden river, its Chemical oxygen demand, biochemical oxygen demand, ammonia nitrogen and fecal coliform are seriously exceeded, as shown in table 5, and emissions of pollutants. The above results show that the main source of pollutants in the underground river of Muerdong is the excrement pollution from the large-scale farms in the upper reaches of the river. Combined with the investigation results in the region, the breeding farms and pig farms of DK company located in the area of rongyue-yangjiaba, a large amount of sewage and excrement produced in the production process is the main source of pollutants.

| Monitoring Point                      | PH  | Permanganate (mg/L) | COD (mg/L) | BOD5 (mg/L) | Ammonia nitrogen (mg/L) | Fecal coliform (M/U/L) |
|--------------------------------------|-----|---------------------|------------|-------------|------------------------|-----------------------|
| W6 Rongrao Surface water             | 7.5 | 1.71                | 30         | 1.2         | 0.062                  | 26000                 |
| Q1                                   | 7.7 | 5.30                | 21         | 5.11        | 6.10                   | 32000                 |
| Monitoring Section of Qingping river (first quarter of 2020) | 8.3 | 1.1                 | 4          | ND          | 0.202                  | 1300                  |
| Q4                                   | 7.8 | 0.72                | 1          | ND          | ND                     | 80                    |
| Standard value of surface water      | 6-9 | 6                   | 20         | 4           | 1.0                    | 10000                 |

4 Conclusions and recommendations

(1) The groundwater of Qingping River Muerdong is mainly affected by Muerdong-qingping River groundwater unit (unit I).

(2) There are four main sub-systems in underground river area of Muerdong. Dajiing karst water system and Tanping River Karst water system are finally discharged through Q4, Q5 and Q6 Karst Springs or underground rivers of Muerdong River, which are not polluted. The outlet points of Yangjiaba Karst water system and Biyan karst water system are Q1, Q2 and K35 in Muerdong River.

(3) The main pollution source of Muerdong underground river is the karst water system of Yangjiaba. Located in the area of chongyue-yangjiaba DK breeding farm and breeding pig farm, a large number of sewage and excrement produced in the production process are the main sources of pollutants. The pollution type of underground water in Muerdong underground river is mainly livestock and poultry excrement, and it is mainly caused by pig excrement.

(4) Based on the comprehensive analysis of the time and process of water pollution discovery and the change of the concentration of each pollutant index in water quality analysis, the polluted karst water system is centralized and discontinuously discharged into underground karst underground river pipelines through falling water cave and Vertical Karst Cave.

(5) The water source area of Muerdong River is located in the strong karst area, and the geological
The environment is fragile. The suitability of developing large-scale aquaculture in Muerdong underground river supply area is poor. It is suggested that the detrital rock distribution area should be selected for the site selection of the new breeding farm.

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