Study on the Chemical Characteristics of the Water Environment in the Middle and Lower Reaches of the Tao River

Zhaoxia Zhu*, Jinqi Liu, Chungang Jing

Water Environment Monitoring Center of Gansu Province, Lanzhou, Gansu Province, 730000, China

*Corresponding author’s e-mail: 50562668@qq.com

Abstract. In this paper, the water in the middle and lower reaches of the Tao River was selected as the research object, the chemical characteristics of water environment in the middle and lower reaches of Tao River were studied and the water quality was evaluated based on the comparative analysis of the data of three monitoring stations for one year. The results show that the contents of HCO$_3^-$, SO$_4^{2-}$ and Ca$^{2+}$ are high in the middle and lower reaches of Tao River, and the water quality belongs to alkaline medium salinity water, and the salinity increases with the increase of HCO$_3^-$. The pH value, total hardness, salinity and main ion content in the middle and lower reaches of the river reach the requirements of the GB5749-2006 Sanitary Standard for Drinking Water or the Class III water quality standard of the surface water environment of GB3838-2002, and which proves the water quality is good.

1. Introduction

As an important part of terrestrial freshwater resources, the river is the most active part of the earth's water circle, its physical and chemical properties not only characterize the environmental quality of water body, the chemical characteristics of regional environment, the distribution and migration and transformation of water elements, but also have an important response relationship with climate change, topography and the formation of rock and mineral characteristics [1,2]. In recent years, due to the increase of human activities, human fact has become an important factor affecting the chemical composition of river water. Therefore, through the analysis of the natural conditions and chemical composition of ions in the river basin, the main sources and influencing factors of ions in the river can be distinguished [3]. At present, the hydrochemistry of river water in China is mostly concentrated in Yangtze River, Yellow River, Pearl River and other large water systems [4-8], but there is a lack of systematic research data for some small watersheds. The research of Tao River mainly focuses on the development of water resources and ecological protection. The basic chemical composition and environmental background value of the river have been discussed by hydrochemistry research.

In order to improve the drought and water shortage in the central part of Gansu, the water supply project of the main body of the Jiudianxia Water Control Project has been started, and the development and utilization of water resources in the Tao River watershed will usher in a new challenge, and the water environment quality and the water ecological system safety problems will become a major problem. Therefore, it is important to study the hydrochemistry of the river water in Tao River watershed, and analyze the physical and chemical properties of the river, the composition of
the main ions and its temporal and spatial changes, which is also of great significance in the evaluation of water resources and environmental protection.

2. Overview of the study area
The Tao River watershed is located in the south of Gansu Province, between 101°52′N-104°19′N and 34°03′E-35°55′E. The four sides of the river watershed are adjacent to the river watershed and the river watershed of the Yangtze River, and the Longling Mountain and the Daxia River watershed are the boundary of the river watershed, and the north and south are adjacent to the main stream of the Yellow River. Tao River, as the largest tributary of the upper reaches of the Yellow River, has a total watershed area of 25527km² and an average runoff of 4.92 billion m³, which carries the important function of water resources allocation in western China, especially in central Gansu, and directly affects the economic and social development of central Gansu and its surrounding areas.

In this study, the sampling data of three monitoring stations in the middle and lower reaches of Tao River are Minxian Water quality Monitoring Station, Lijiacun Hydrological Monitoring Station and Hongqi Hydrological Monitoring Station (Fig. 1). The sampling time is from February 2018 to December 2018 and sampling every two months, and the sample analysis method is the Water and Wastewater Monitoring and Analysis method of the State Environmental Protection Bureau.

3. Research results and analysis

3.1 Main ions in the water of the middle and lower reaches of Tao River
According to the monitoring data of the three monitoring stations in the middle and lower reaches of the river, the main water chemical composition in the middle and lower reaches of the river is $\text{HCO}_3^->\text{Ca}^{2+}>\text{SO}_4^{2-}>\text{Na}^+>\text{Mg}^{2+}>\text{Cl}^->\text{CO}_3^{2-}>\text{K}^+$.

3.1.1 $\text{HCO}_3^-$. $\text{HCO}_3^-$ is the main anion in the middle and lower reaches of Tao River. The annual $\text{HCO}_3^-$ of Minxian Water quality Monitoring Station in the middle reaches of Tao River was 186~247mg/L, the mean value was 218.5mg/L, the average annual $\text{HCO}_3^-$ of Lijiacun Water quality Monitoring Station in the lower reaches of Tao River was 205mg / L, and the mean annual $\text{HCO}_3^-$ of Red Banner Water quality Monitoring Station was 181~239mg/L (Fig.2(a)). $\text{H}_2\text{CO}_3^-\text{HCO}_3^->\text{CO}_2$ in

Figure 1. Geographic coordinates of three water quality monitoring stations in the middle and lower reaches of Tao River.
natural water is generally in equilibrium, but when pH value is about 8.5, carbonate ions in river water mainly exist in the form of \( \text{HCO}_3^- \), and its content will directly affect the total salt content, and then affect the chemical stability of water.

### 3.1.2 \( \text{Ca}^{2+} \)

\( \text{Ca}^{2+} \) is one of the main cations in the middle and lower reaches of the river. The water quality monitoring station of Minxian County in the middle reaches of the Tao River is monitoring the water quality of the whole year, the average value of \( \text{Ca}^{2+} \) is 43.4~61.8mg/L, the mean value is 52.1mg/L, and the water quality monitoring station of Lijia Village in the lower reaches of the river is about 41.0~62.0mg/L, the mean value is 52.3mg/L. The monitoring water quality of the water quality monitoring station of the red flag is 31.2~79mg/L, and the mean value is 55.2 mg/L (Fig.2(b)).

\( \text{HCO}_3^- \) and \( \text{Ca}^{2+} \) mainly come from the dissolution of carbonate rocks such as marl, limestone, dolomite and so on. The dissolution process is related to the content of \( \text{CO}_2 \) in water. The anions in the middle and lower reaches of Tao River are mainly \( \text{HCO}_3^- \), while the cations are mainly \( \text{Ca}^{2+}, \text{Mg}^{2+} \) and \( \text{K}^+ \). The reason is that the rocks with more carbonate minerals are distributed in the upper reaches of Tao River, and the hydrothermal conditions are sufficient, which creates good conditions for carbonate dissolution. It also leads to the accumulation of enough \( \text{HCO}_3^- \) and \( \text{Ca}^{2+} \) in the water, which occupies an absolute advantage in hydrochemistry, and the proportion of \( \text{HCO}_3^- \) and \( \text{Ca}^{2+} \) in the river increases gradually with the passage of time.

### 3.1.3 \( \text{Mg}^{2+} \)

The annual \( \text{Mg}^{2+} \) of Minxian Water quality Monitoring Station in the middle reaches of Tao River was 11.3~16.6mg/L, the mean value was 14.13mg/L, the annual \( \text{Mg}^{2+} \) of the lower reaches of Tao River was 7.2~20.2mg/L, the average value was 15.5mg/L, and the annual \( \text{Mg}^{2+} \) of Red Banner Water quality Monitoring Station was 6.37~26.00mg/L, the mean value was 14.92mg/L (Fig. 2(c)).

### 3.1.4 \( \text{Cl}^- \)

The annual \( \text{Cl}^- \) of Minxian Water quality Monitoring Station in the middle reaches of Tao River was 1.49~4.93mg/L, the mean value was 2.89mg/L, the annual \( \text{Cl}^- \) of the lower reaches of Tao River was 2.41~5.46mg/L, the average value was 4.20 mg/L, and the annual \( \text{Cl}^- \) of Red Banner Water quality Monitoring Station was 8.68~15.8mg/L, the mean value was 11.44mg/L (Fig. 2(d)).

### 3.1.5 \( \text{SO}_4^{2-} \)

The annual \( \text{SO}_4^{2-} \) of Minxian Water quality Monitoring Station in the middle reaches of Tao River was 15~29.2mg/L, the mean value was 21.2mg/L, the annual \( \text{SO}_4^{2-} \) of the lower reaches of Tao River was 13~24.7mg/L, the average value was 20.0 mg/L, and the annual \( \text{SO}_4^{2-} \) of Red Banner Water quality Monitoring Station was 24.2~92.9mg/L, the mean value was 45.0mg/L (Fig. 2(e)).

### 3.1.6 \( \text{Na}^+ \)

The annual \( \text{Na}^+ \) of Minxian Water quality Monitoring Station in the middle reaches of Tao River was 3.22~12mg/L, the mean value was 7.82mg/L, the annual \( \text{Na}^+ \) of the lower reaches of Tao River was 3.3~13.3mg/L, the average value was 8.27mg/L, and the annual \( \text{Na}^+ \) of Red Banner Water quality Monitoring Station was 5.8~61.5mg/L, the mean value was 23.7mg/L (Fig. 2(f)).

### 3.1.7 \( \text{K}^+, \text{MnO}_4^- \) and \( \text{CO}_3^{2-} \)

Through the monitoring and analysis, the proportion of these ions in the river is low, and the variation in the whole year is small, but the overall trend is that the middle reaches of the river is higher than that of the downstream.
Figure 2. Main ion content of three stations in the middle and lower reaches of Tai River: (a) HCO$_3^-$; (b) Ca$^{2+}$; (c) Mg$^{2+}$; (d) Cl$^-$; (e) SO$_4^{2-}$; (f) Na$^+$.  

3.2 Physicochemical properties of river water

3.2.1 pH value. The annual pH value of monitoring water quality at Minxian Water quality Monitoring Station in the middle reaches of Tao River was 8.2~8.7, with an average value of 8.37; the annual pH value of Lijiacun Water quality Monitoring Station in the lower reaches of Tao River was 8.3~8.5, with an average value of 8.38; the annual pH value of Red Flag water quality monitoring station was 8.3~8.5, with an average value of 8.37; The pH values of the three monitoring points in dry season are higher than those in high water season (Fig.3(a)). The water quality of the middle and lower reaches of Tao River is alkaline, which is mainly caused by the dissolution of carbonate rocks widely distributed in the upper reaches of Tao River, which leads to the formation of bicarbonate buffer system in water.

3.2.2 Salinity. The annual salinity of Minxian water quality monitoring station in the middle reaches of Tao River is 294~364mg/L, the mean value is 323mg/L, the annual salinity of Lijiacun water quality monitoring station in the lower reaches of Tao River is 216~313mg/L, the mean value is 276.17mg/L, and that of Red Flag water quality monitoring station is 272~446mg/L, the mean value is 346mg/L(Fig.3(b)). Compared with the middle reaches of Tao River watershed, the salinity of the lower reaches is higher. According to the salinity classification standard of SL395-2007, the water with salinity less than 300mg/L belongs to low salinity water, but 12 of the 18 monitoring data have mineralization value higher than 300mg/L, which indicates that this section of river water belongs to medium salinity water and moderate hard water, which is consistent with the high HCO$_3^-$ content in this section. The salinity shows that the total salt level in the water directly affects the water migration coefficient of the elements, and it is an important index to reflect the physical and chemical properties of water quality. Similarly, according to the salinity greater than 500mg/L, the natural background water quality of surface water has become worse, while the water quality mineralization value of 18 monitoring stations in the middle and lower reaches of Tao River is lower than 500mg/L, which indicates that the natural background water quality in the middle and lower reaches of Tao River is less polluted.
3.2.3 Electrical conductivity. The annual conductivity of Minxian water quality monitoring station in the middle reaches of Tao River is 316~512μs/cm, the average value is 385.67 μs/cm; The annual conductivity of Lijiacun water quality monitoring station in the lower reaches of Tao River is 367~454μs/cm, The average value is 402.33μs/cm; The annual conductivity of Red Flag water quality monitoring station is 403~608μs/cm, the average value is 488μs/cm. It is found that the conductivity of the middle and lower reaches of Tao River in the period of February to April and October to December is relatively larger than that of June to August. At the same time, compared with the middle reaches of Tao River watershed, the electrical conductivity of the lower reaches is higher, which indicates that the water quality in the middle reaches is better than that in the lower reaches (Fig.2(c)).

3.2.4 Dissolved oxygen. The annual dissolved oxygen of Minxian water quality monitoring station in the middle reaches of Tao River is 8.17~10.5mg/L, the mean value is 8.90mg/L, the annual dissolved oxygen of Lijiacun water quality monitoring station in the lower reaches of Tao River is 7.1~10.2mg/L, the average value is 8.8mg/L, and that of Red Flag water quality monitoring station is 7.0~10.3mg/L, the mean value is 9.0mg/L(Fig.3(d)). Compared with the middle reaches of Tao River watershed, the dissolved oxygen of the lower reaches is higher.

3.2.5 Total hardness (in CaCO₃). The annual total hardness of Minxian water quality monitoring station in the middle reaches of Tao River is 155~214mg/L, the mean value is 188.3mg/L, the annual total hardness of Lijiacun water quality monitoring station in the lower reaches of Tao River is 157.1~217mg/L, the average value is 194.36mg/L, and that of Red Flag water quality monitoring station is 173.16~224mg/L, the mean value is 199.53mg/L(Fig.3(e)). Compared with the middle reaches of Tao River watershed, the total hardness of the lower reaches is higher.
4. Conclusions
The main results are as follows:

(1) the water quality of the middle and lower reaches of Tao River belongs to alkaline and medium salinity water, and its salinity increases with the increase of HCO$_3^-$, and the main hydrochemical composition of the river is HCO$_3^-$>Ca$^{2+}$>SO$_4^{2-}$>Na$^+$> Mg$^{2+}$>Cl$^-$> CO$_3^{2-}$>K$^+$.

(2) In the middle and lower reaches of Tao River, the contents of HCO$_3^-$, SO$_4^{2-}$ and Ca$^{2+}$ are high, and the chemical type is calcium and sodium bicarbonate type water.

(3) In the middle and lower reaches of Tao River, HCO$_3^-$, K$^+$, Cl$^-$ and Ca$^{2+}$ mainly come from the dissolution of carbonate rocks such as marl, limestone and dolomite, and their contents increase gradually with the passage of time.

(4) The pH value, total hardness, salinity and the content of main ions and trace elements in the middle and lower reaches of Tao River meet the requirements of GB5749-2006 hygienic Standard for drinking Water or GB3838-2002 Surface Water Environmental quality Standard III, so the water quality is good.

Acknowledgments
Financial supports for this project are from the Gansu Water Conservancy Science Experimental Research Project (2018-35) and the Special Project of Basic Scientific Research Fee of Institute of Earthquake Prediction, China Earthquake Administration (Grant No. 2014IESLZ01).

References
[1] Pu Junbing, Yuan Daoxian, Jiang Yongjun, et al..(2010) Hydrogeochemistry and environmental meaning of Chongqing subterranean karst streams in China [J]. Advances in water science, 21(5): 628-634. (in Chinese)
[2] Wang Zhe, Lu Li, et al..(2013) Numerical simulation of the evolution of karst groundwater system [J]. Journal of Yangtze River scientific research institute, 30(7):22-28. (in Chinese)
[3] Bao Li-ran, Li Xiao-dong, Liu Xiaolong. (2010) Space-time variation of chemical composition of major ions in Jialing River [J]. Advances in science and technology of water resources, 30(4): 36-40. (in Chinese)
[4] ELDERFIELD H, UPSTILL -GODDARD R, SHOLKOVITZ E R. (1990) The rare earth elements in rivers, estuaries, and coastal seas and their significance to the composition of ocean waters[J]. Geochimica et CosmochimicaActa, 54(4): 971-991.
[5] REEDER S W, HITCHON B, LEVINSON A A. (1972) Hydrogeochemistry of the surface waters of the Mackenzie river drainage basin, Canada-I. Factors controlling inorganic composition[J]. Geochimica et CosmochimicaActa, 36(8): 825-865.
[6] Chen Jingsheng, Guan Wenrong, et al..(1998) Evolution in water quality and its relation with environmental acidification in the upper and middlereaches of the Yangtze River [J]. Acta scientiae circumstantiae, 18(3): 265-270. (in Chinese)
[7] Chen Jingsheng, Xia Xinghui. (1999) Progress in research on river hydrochemistry in China [J]. Scientiageographicasinica, 19(4): 290-294. (in Chinese)

[8] Zhang Litian, Chen Jingsheng. (2000) The relationship between the composition of the major ion of river of China and regional natural factors[J]. Scientiageographicasinica, 20 (3): 236-240. (in Chinese)