Analysis on the Influencing Factors of Iron and Manganese Content in Shallow Groundwater in the Water Source-Area near the Feng River in Xi'an

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Abstract

Iron and manganese ions, as the main contribution indicator of super-class III shallow groundwater in the western suburbs of Xi'an, seriously threaten the safety of local water supply and the health of residents. Based on data collection and hydrogeological survey, this paper studies the concentration of iron and manganese in groundwater by collecting and analyzing 52 groups of groundwater samples, and analyzes the possible sources of iron and manganese in consideration of human factors such as hydrogeological conditions and surface pollution input. The results showed: (1) The highest iron content exceeded the Class III water quality standard by 1.03 times, and the highest manganese content exceeded the Class III water quality standard by 3.92 times. The water sample points exceeding Class III accounted for 9.5% and 26.2% of the total water sample points respectively. (2) The content of iron and manganese in the water of Feng River is 8.47% and 19.69% of the groundwater respectively. Therefore, the higher iron and manganese in individual wells near the source of Feng River have no obvious relationship with Feng River. (3) According to drilling data, the iron and manganese content in different rock masses is silty clay>round gravel>fine sand, medium-coarse sand, and the distribution of iron and manganese content is positively correlated. (4) In the experiment of the iron and manganese release law in the rock mass, it was observed that the iron and manganese in the overlying water experienced three stages of rapid increase, fall and stabilization. When the final release stabilizes, the release rate of manganese in the rock mass is higher than that of iron. The manganese content in the overlying water is 0.010~0.057mg/L, the release rate is 0.02%~0.05%, and the iron content is 0.004~0.023mg/ L, the release rate is less than 0.01%, and the higher pH in the water environment has a significantly higher inhibitory effect on the release of iron in the rock mass than manganese.

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Keywords: Hydrogeochemistry; water pollution; Fe ion; Mn ion

ABSTRACT: Iron and manganese ions, as the main contribution indicator of super-class III shallow groundwater in the western suburbs of Xi'an, seriously threaten the safety of local water supply and the health of residents. Based on data collection and hydrogeological survey, this paper studies the concentration of iron and manganese in groundwater by collecting and analyzing 52 groups of groundwater samples, and analyzes the possible sources of iron and manganese in consideration of human factors such as hydrogeological conditions and surface pollution input. The results showed: (1) The highest iron content exceeded the Class III water quality standard by 1.03 times, and the highest manganese content exceeded the Class III water quality standard by 3.92 times. The water sample points exceeding Class III accounted for 9.5% and 26.2% of the total water sample points respectively. (2) The content of iron and manganese in the water of Feng River is 8.47% and 19.69% of the groundwater respectively. Therefore, the higher iron and manganese in individual wells near the source of Feng River have no obvious relationship with Feng River. (3) According to drilling data, the iron and manganese content in different rock masses is silty clay>round gravel>fine sand, medium-coarse sand, and the distribution of iron and manganese content is positively correlated. (4) In the experiment of the iron and manganese release law in the rock mass, it was observed that the iron and manganese in the overlying water experienced three stages of rapid increase, fall and stabilization. When the final release stabilizes, the release rate of manganese in the rock mass is higher than that of iron. The manganese content in the overlying water is 0.010~0.057mg/L, the release rate is 0.02%~0.05%, and the iron content is 0.004~0.023mg/ L, the release rate is less than 0.01%, and the higher pH in the water environment has a significantly higher inhibitory effect on the release of iron in the rock mass than manganese.

ABSTRACT: Iron and manganese ions, as the main contribution indicator of super-class III shallow groundwater in the western suburbs of Xi'an, seriously threaten the safety of local water supply and the health of residents. Based on data collection and hydrogeological survey, this paper studies the concentration of iron and manganese in groundwater by collecting and analyzing 52 groups of groundwater samples, and analyzes the possible sources of iron and manganese in consideration of human factors such as hydrogeological conditions and surface pollution input. The results showed: (1) The highest iron content exceeded the Class III water quality standard by 1.03 times, and the highest manganese content exceeded the Class III water quality standard by 3.92 times. The water sample points exceeding Class III accounted for 9.5% and 26.2% of the total water sample points respectively. (2) The content of iron and manganese in the water of Feng River is 8.47% and 19.69% of the groundwater respectively. Therefore, the higher iron and manganese in individual wells near the source of Feng River have no obvious relationship with Feng River. (3) According to drilling data, the iron and manganese content in different rock masses is silty clay>round gravel>fine sand, medium-coarse sand, and the distribution of iron and manganese content is positively correlated. (4) In the experiment of the iron and manganese release law in the rock mass, it was observed that the iron and manganese in the overlying water experienced three stages of rapid increase, fall and stabilization. When the final release stabilizes, the release rate of manganese in the rock mass is higher than that of iron. The manganese content in the overlying water is 0.010~0.057mg/L, the release rate is 0.02%~0.05%, and the iron content is 0.004~0.023mg/ L, the release rate is less than 0.01%, and the higher pH in the water environment has a significantly higher inhibitory effect on the release of iron in the rock mass than manganese.

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1. INTRODUCTION

Water resources play an important role in promoting orderly economic development, ensuring the basic lives of urban and rural residents, and maintaining ecological balance. Surface water and groundwater are important components of water resources. Compared with surface water, groundwater is more widely distributed and requires less investment in mining and utilization. Especially in some arid and semi-arid areas, surface water resources are relatively scarce, and the role of groundwater is particularly obvious. In the development and utilization of groundwater, the riverside groundwater source has sufficient water quantity and good water quality, so riverside mining has become an important method of groundwater utilization.

In recent years, due to the intensification of human activities, the impact on groundwater is increasing and the dependence is increasing. While developing and utilizing groundwater resources, we are facing one of the most serious problems-groundwater pollution. Groundwater pollution refers to the phenomenon that groundwater quality is deteriorating under the influence of human activities. In addition to the impact of human activities, the natural geological environment may also have inferior quality water[1-5]. In the evaluation of groundwater pollution, it is difficult to determine the background value or the control value due to the influence of human activities. It often includes groundwater pollution caused by some natural factors, which exaggerates the evaluation results and cannot correctly provide a scientific basis for proposing groundwater pollution prevention measures[6-11]. According to data, the quality of most of the shallow groundwater in Xi'an is mainly Fe, Mn, and ammonia nitrogen. Among them, Fe and Mn are listed as secondary pollutants in the "Secondary Drinking Water Standards: Guidance for Nuisance Chemicals" issued by the US Environmental Protection

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Data Availability Statement
Research data are not shared.

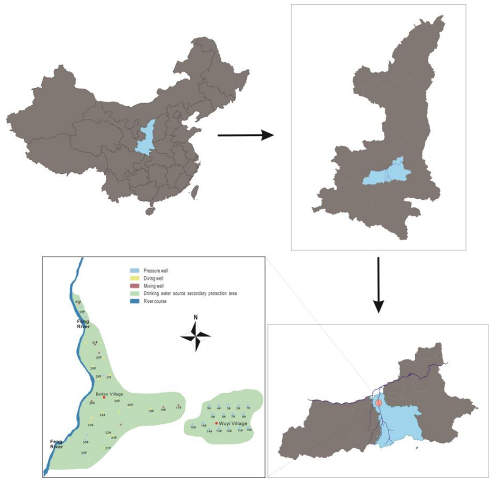


Figure 1. Geographical location of the research area

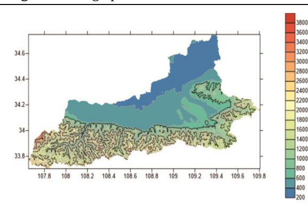


Figure 2. Xi'an City Elevation

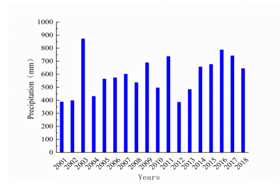


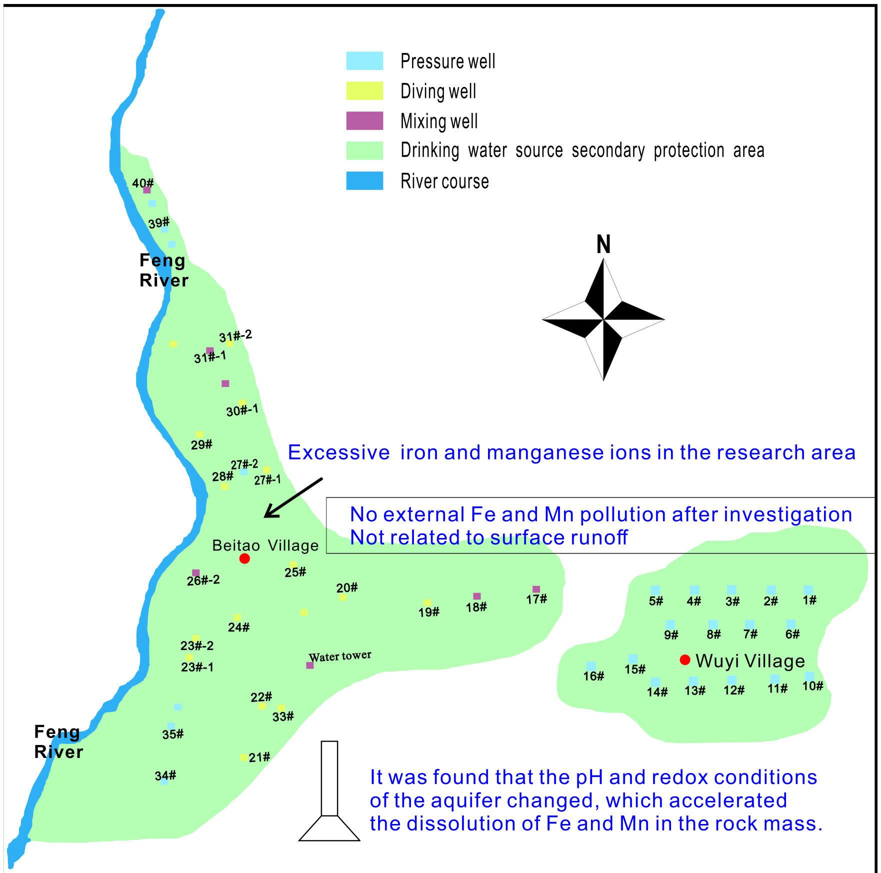
Figure 3. Histogram of annual precipitation distribution in Xi'an from 2001 to 2018

Table 1. Formation lithology distribution statistics table

Quaternary System	Numbering	Depth (m)	Rock thickness (m)	Lithology
Lower alluvial deposits of the Holocene series (Q_4^{1al})	1	0~1.7	1.7	plain fill
	2	1.7~3.0	1.3	loess
	3	3.0~7.8	4.8	Fine sand
	4	7.8~15.0	7.2	Coarse sand
	5	15.0~19.9	4.9	Round gravel
Middle Pleistocene alluvial horizon (Q_2^{al})	6	19.9~26.5	6.6	Fine sand
	7	26.5~29.8	3.3	Coarse sand
	8	29.8~36.1	6.3	Fine sand
	9	36.1~40.0	3.9	Round gravel
	10	40.0~41.3	1.3	Silty clay
	11	41.3~52.0	10.7	Fine sand
	12	52.0~65.0	13.0	Coarse sand
	13	65.0~67.0	2.0	Fine sand
	14	67.0~67.5	0.5	Silty clay
	15	67.5~70.0	2.5	Coarse sand
	16	70.0~74.8	4.8	Round gravel
	17	74.8~78.2	3.4	Silty clay
	18	78.2~80.0	1.8	Fine sand
	19	80.0~92.9	12.9	Coarse sand
	20	92.9~96.4	3.5	Silty clay
	21	96.4~142.0	45.6	Coarse sand
	22	142.0~145.0	3.0	Silty clay
	23	145.0~147.8	2.8	Coarse sand
	24	147.8~154.8	7.0	Round gravel
	25	154.8~179.5	24.7	Coarse sand
	26	179.5~184.0	4.5	Fine sand
	27	184.0~187.5	3.5	Coarse sand
	28	187.5~191.0	3.5	Round gravel
	29	191.0~250.5	59.5	Coarse sand
Alluvial lacustrine strata of Lower Pleistocene (Q_1^{al+l})	30	250.5~256.0	6.0	Silty clay
	31	256.0~261.0	5.0	Fine sand
	32	261.0~268.0	7.0	Round gravel
	33	268.0~285.0	17	Coarse sand

Table 2. Geographical location and time of sampling point

Well number	Sampling date: the first time	Sampling date: the second time	Sampling date: the third time	Longitude(E)	Latitude(N)
17#	2019.05	2019.06	2019.07	108°47′05.88″	34°16′48.86″
18#	2019.05	2019.06	2019.07	108°46′48.50″	34°16′48.83″
19#	2019.05	2019.06	2019.07	108°46′14.50″	34°16′48.84″
23-1#	2019.05	2019.06	2019.07	108°44′51.22″	34°16′49.87″
23-2#	2019.05	2019.06	2019.07	108°44′51.44″	34°16′49.96″
26-2#	2019.05	2019.06	2019.07	108°45′06.15″	34°17′19.64″
27-1#	2019.05	2019.06	2019.07	108°45′09.36″	34°17′39.24″
27-2#	2019.05	2019.06	2019.07	108°45′08.80″	34°17′39.11″


Pressure well
Diving well
Mixing well
Drinking water source secondary protection area
River course
N
Feng River
40#
39#
31#-2
31#-1
30#-1
29#
28#
27#-2
27#-1
Excessive iron and manganese ions in the research area
No external Fe and Mn pollution after investigation
Not related to surface runoff
Beitao Village
26#-2
25#
20#
19#
18#
17#
24#
23#-2
23#-1
Water tower
22#
33#
35#
21#
34#
Feng River
5#
4#
3#
2#
1#
9#
8#
7#
6#
16#
15#
Wuyi Village
14#
13#
12#
11#
10#
It was found that the pH and redox conditions of the aquifer changed, which accelerated the dissolution of Fe and Mn in the rock mass.