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A STUDY ON THE EVOLUTION OF GROUNDWATER POLLUTANTS AND CAUSES OF FORMATION IN MANZHOULI

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ABSTRACT: Studying the evolution of groundwater pollutants and the causes of formation in Manzhouli is important and necessitous as the present water source of the production and living in Manzhouli is just groundwater and the water crisis is staring Manzhouli people in the face. The evolution of pollutants in groundwater in Manzhouli was derived based on the continuously monitoring between 1989 and 1999. In total, the quality of groundwater in Manzhouli is good except that the content of F is exceeding the standard. The quality of groundwater varies seasonally. The content of pollutants in high water is higher than in the low water except pH and As. The yearly evolution shows the regime like the damp surge. The evolution of pH is inverse to NO_3-N and F after 1999. The courses of formation of the evolution of the content of the pollutants in groundwater in Manzhouli are the supply of runoff, the feature of rock, the time the water being stayed in the layers and the chemical field. Being affected by the supply of ground surface and hydrogeology condition, the contents of pollutant are higher in the May than in September and the yearly evolution is undulance. In total, the pollutants in the deeper layers are less than in the upper layers. Explosion water in the deeper layers, using the techniques of cutting F and minifying the pollutants caused by human being are the sound countermeasures in Manzhouli.

KEY WORDS: : Manzhouli; groundwater; pollutants; causes of formation

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Manzhouli, a city of Halun Buir, is located at 117°12′ - 117°53′E, 49°19′ - 49°41′N with a total area 18.73km^2. Its morphologies are mainly hills and sloping fields and the average height above sea level is 654m. It is rounded by the hills and higher in the south part and lower in the north part. It's climate is the semi-dry climate of mid-temperate zone with the cold and windy winter and cool and short summer. It is dry in spring and the temperature decreases quickly in the autumn with the earlier frenzying. The yearly mean temperature is -1.3℃, the yearly mean precipitation 299.5mm and the yearly evaporation 1200 - 1500mm. The present water source of the production and living is just the groundwater. With the development of the city and the increasing of population, the water level of groundwater is decreasing step by step. The exploitation of groundwater is 0.3 million m^3 more than the supply. The crisis of water is staring Manzhouli people in the face and will limit the advancing of Manzhouli. Studying the evolution of pollutants in the groundwater

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in Manzhouli and its courses of formation, the academic base of the exploitation and management will put out, while it will be the reference of the management of the drought region of China.

1 THE HYDRO-GEOLOGICAL STATUE

Manzhouli City lies in the seam between outer Baikal gofer and Da Hinggan Mountains gofer where is in the northwest of Erguna —Hulun Lake sunder. The especially tectonic environment controls its geologic structure, volcano-magma activity and groundwater. (The Editor Group of the city Mark of Manzhouli, 1999; Xu, *et al.*, 1995) The stratum of the area is Devonian-Wuluer group, upper Jurassic-Tamulangou and Shangkuli group, later Cretaceous-Damoguaihe group, and the alluvium and diluvium of the Quaternary system Holocenc according to the order that is from old to new. Invasive rocks include early granite, alaskite and syenogranite of Yanshan Mountains. The regional tectonic gives priority to rupture. The gofer includes limestone mill anticline and litter coalpit syncline. The area remains with embossed gofer strap and its groundwater relies mainly on fault water. According to lithology, imbed condition, aquosity and perviousness, the aquafer can divide into five parts. The first part is the Quaternary system gravel interstice water that is mainly distributed in little river valley and valley among hills. The aquafer is made up of gravel, clay and sandy scree. From contributing region to runoff area, water-bearing medium takes on a characteristic that its granularity gradually minishes; the aquafer varies from singleness to multilayer and its thickness largens; sitting depth of water level varies from deepness to shallowness and amount of water gradually increases. In the area, hydrochemistry types of groundwater include $HCO_3-Na \cdot Mg \cdot Ca$, $HCO_3 \cdot SO_4-Na \cdot Ca$ and $HCO_3 \cdot SO_4-Na \cdot Ca \cdot Mg$ and total salinity is 0.43 – 1.0g/L. The second part is the hole-cranny aquafer of later Cretaceous-gravel that is distributed in the west of Kaifang Hill and Little Coalpit. The aquafer is made up of white sandstone and tuff sandstone. Hydrochemistry types of groundwater is $HCO_3 \cdot SO_4-Na$ and total salinity is 0.8 – 1.0g/L. The third part is the cranny aquafer of upper Jurassic-lava that is distributed in the north and east far and wide. According to lithology and water content, the aquafer can be divided into two layers: 1) basaltic-andesite whose hydrochemistry types is HCO_3-Na and total salinity is 1.56g/L; 2) the cranny aquafer of rhyolite, tuff and volcanic breccia that is distributed in the west, north of Little Coalpit, and Xiaolongyan Mountain, Sitou Mountain, Lubingnan Mountain, Dayong Mountain and Damu Mountain, etc. Water-bearing medium includes rhyolite, tuff, andesite porphyry and volcanic breccia whose rocky joint is vestigial and the ratio of fissure is 0.53% – 1.42%. The thickness of aquafer is 30 – 40m and sitting depth of water level is 5 – 15m. The fourth part is the cranny-karst aquafer of Devonian-marble, dolomite-crystalline limestone that is mainly distributed in the area of limestone mill. Its square measure is only $3km^2$. The aquafer is made up of marble and crystalline limestone and its fissure is well-grown. The fifth part is the cranny aquafer of Yanshan-granite that is distributed in the south of the city. Water-bearing medium is made up of granite, dolomitite and beschtauite, etc. Hydrochemistry types of groundwater is $HCO_3 \cdot SO_4-Ca \cdot Mg$ and total salinity is 0.69g/L.

2 MATERIAL AND METHODS

2.1 Sampling

The water samples were collected in six wells namely old No 1, old No 5, new No 1, new No 2, Seed Field and Vestibule School in Manzhouli. The type of all these wells is cranny aquafer of hardpan, the depth of the wells is 30m except that the well of Vestibule School is 109m. The water samples were collected two times namely low water(the last ten days of May) and high water(the last ten days of Sept.) a year. The water samples were analysis in Lab loaded by polyethylene bottles. The Manzhouli Monitor Station of Environment derived the data between 1989 and 1998, and the data of 1999 were got by the authors at the Analytical Center of Changchun Institute of Geography, the Chinese Academy of Sciences.

2.2 Disposal of Data

Disposal of data was finished with EXCEL97 and SPSS9.0. Eliminating the abnormal values with CRUBBS after the data were input into computer, organize the data with year and then test the data.

3 RESULTS AND DISCUSSION

3.1 The General of Water Quality

The water quality was assessed with the second type of Sanitation Quality Standard for Drinking Water (GB5084 - 85) (SQSDW) after the average values of all wells and all times were derived (Table 1).

Table 1 The monitoring results of groundwater quality

Sampling site	pH	TH($CaCO_3$)	COD_{Mn}	NO_3-N	F	As	Cr^{6+}
New No 1	7.52	301.77	1.59	3.69	3.69	0.017	0.005
New No 2	7.77	278.77	1.37	3.59	3.59	0.013	0.005
Old No 3	7.69	245.37	1.48	6.18	6.18	0.005	0.003
Old No 5	7.71	301.27	1.46	3.91	3.91	0.012	0.002
Vestibule school	7.68	218.83	1.01	0.13	0.13	0.005	0.002
Seed field	7.75	187.00	1.22	2.08	2.08	0.005	0.003
SQSDW	6.5 - 8.5	450	-	20	20	0.05	0.05

Note: the units of water quality are mg/L except pH.

In total, the groundwater quality in Manzhouli is good. For the cycle of water, the content of F is the main pollutant and more than the SQSDW. Manzhouli is the area of high F because of the hydrogeology (YAN *et al.*, 2000). The pollutants were enriched after the groundwater goes into the system of urban living and producing systems. The feasible countermeasures decreasing the content of F should be adopted.

3.2 Seasonally Evolution and the Courses of Formation

The area where Manzhouli locates has the high latitude. The groundwater can't be supplied for the surface water being frozen between Sept. and May next year, and this period is the low water. While the period remained is the high water. The depth of groundwater is shallow and mainly being supplied by the surface water, so it is affected by the surface water distinctly. With the supplying of surface water during the high water, the ground water increased and the pH decreased. At the same time, the pollutants were increasing. During the low water, with the explosion of the groundwater, the content of pollutants decreased step by step. From Table 2, the seasonally evolution of pollutants is derived. The contents of pollutants except pH and As is more in high water than in the low water and the variation is very clear. The NO_3-N and Cr^{6+} are move distinct, the content in high water is two times in low water.

Table 2 The seasonal evolution of pollutant in groundwater

Time	pH	TH($CaCO_3$) (mg/L)	COD_{Mn} (mg/L)	NO_3-N (mg/L)	F(mg/L)	As(mg/L)	Cr^{6+}(mg/L)
May	7.88	239.10	1.06	2.37	2.11	0.05	0.002
Sept.	7.64	280.90	1.41	4.65	2.30	0.05	0.004

3.3 Yearly Evolution and the Courses of Formation

The non-linearity fit equation of the mainly pollutants characteristic were derived.

$$pH = 6.12 + 2.01t - 0.86t^2 + 0.15t^3 - 0.01t^4 + (3.59E-4)t^5 \quad (R^2 = 0.96904) \quad (1)$$

$$C_F = 2.03 - 0.26t + 0.29t^2 - 0.07t^3 + 0.01t^4 - (2.27E-4)\ t^5 \quad (R^2 = 0.97179) \quad (2)$$

$$C_{NO_3-N} = 3.74 - 6.03t + 5.17t^2 - 1.25t^3 + 0.0.00381t^5 \quad (R^2 = 0.58593) \quad (3)$$

C_F and NO_3-N are the content of F and NO_3-N and t is year.

Fig. 1 is derived after Standardization on the average value of indices. Analyzing the equations above and the figure, an interesting phenomenon was derived. The contents of the pollutants vary waffle. The begin- ning Cyc is about 5 – 7 years. The evolution of pH was inversed to the NO_3-N after 1989 and showing following aspects: 1) the Cyc of pH evolution increase step by step, while the NO_3-N and F decreased. ;2)swing of pH evolution increase step by step, while the NO_3-N and F's decreased; 3) when the pH was at the top-peak, the NO_3-N and F's wings decreased gradually and at the low-peak. This means that the evolution of pH is later than NO_3-N and F's for 3 – 4 years. The courses resulting in this are very complex, but the main reason is the hydrogeology. We can get the reasons of the asynchronism between pH's evolution and NO_3-N and F's from the chemical features of NO_3-N and F. NO_3-N and F are the salt of strong acid, with the increasing of pH, the intention of hydrolyze increased, and the content decreased.

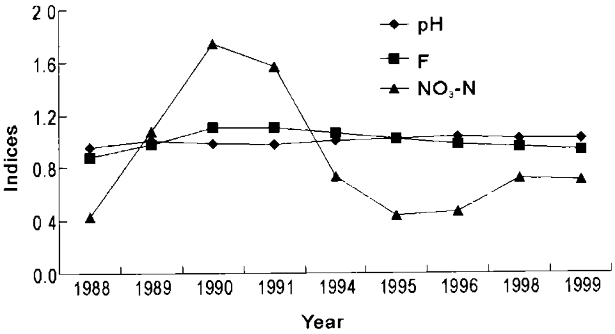

Fig. 1 The evolution of the main indices

3.4 Pollutants in the Groundwater of Different Aquafer

The quality of the different layers varied for the time the water contacting with rocks and the the resource of the water. The water reaches to the deep layers after many times of seepage, and the content of pollutant decreased. At the same time, the time is longer and longer with the seepage of water, and the reaction is more replete, this courses the mineralization degree of the deep ground water increasing. Comparing the average contents of pollutants of the water at the depth of 30m and of the 109m, the following conclusion is derived (Table 3). 1) The pH of shallow water in the high water and low water is the same, and that in high water is little lower than in the low water. The pH of groundwater than in the deeper layer varies obviously, the value in high water being lower than the low water's. 2) The total hardness of the groundwater varies instinctually in the high water and the low wa-

Table 3 The content of pollutants in the different aquafers

Item	Shallow water (30m)		Deep groundwater(109m)	
	Low water	High water	Low water	High water
pH	7.76	7.68	7.86	7.42
$TH(CaCO_3)$(mg/L)	246.84	289.04	200.20	240.10
COD_{Mn}(mg/L)	1.082	1.49	0.96	0.99
NO_3-N(mg/L)	2.972	5.518	0.009	0.339
F(mg/L)	2.11	2.30	2.11	2.30
As(mg/L)	0.0052	0.005	0.003	0.005
Cr^{6+}(mg/L)	0.002	0.005	0.002	0.002

ter. But in total, the content of the shallow groundwater is the higher. 3) The COD_{Mn} content of deep groundwater varies little, however, that of the shallow water is high in the high water and higher than of the deep groundwater. 4) The NO_3-N of groundwater varies between the high and the low water strongly, and that of the deep groundwater is more and is less than the shallow groundwater. 5)The variations of F in the deep groundwater and the shallow groundwater is at the same pace. 6) The content of As in the shallow water rises up with the time, while that in the deep groundwater is different. 7) The content of Cr^{6+} in the shallow groundwater varies strongly, while that in the deep groundwater holds the same.

4 CONCLUSION

The conclusion was derived through the study:

(1) The quality of ground water in Manzhouli is good except that the content of F is exceeding the principle.

(2) The quality of groundwater varies seasonally. The content of pollutants in high water is higher than in the low water except pH and As. The yearly evolution shows the regime like the damp surge. The evolution of pH is inverse to NO_3-N and F after 1999.

(3) The course of formation of the evolution of the content of the pollutants in groundwater in Manzhouli is the supply of runoff, the feature of rock, the time the water being stayed in the layers and the chemical field.

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