MONITORING AND STUDY ON TEMPERATURE CHANGES IN GROUNDWATER HEAT PUMP SYSTEM

Du Jizhong, Professor, Department of Hydrogeology and Environmental geology, Shenyang Institute of Geology and Mineral Resources, Shenyang, China

Yang Ze，Engineer, Department of Hydrogeology and Environmental geology,

Shenyang Institute of Geology and Mineral Resources, Shenyang, China
Wang Guiling, Professor, The Institute of Hydrogeology and Environment Geology, CAGS, Shijiazhuang, CHina

Yu Huiming，Engineer, Department of Hydrogeology and Environmental geology,

Shenyang Institute of Geology and Mineral Resources, Shenyang, China

Abstract: Shenyang is the city where groundwater heat pump systems are most widely used now in China. About 400 groundwater heat pump systems are in using. In order to study the temperature changes in soil and the aquifer, monitoring systems are built where groundwater heat pump systems are in using. By analysing the aquifer information and temperature curve drawing with monitoring data, we discuss the temperature transfer in different aquifer (soil) and geo-environmental effect of heat pump system.

Key Words: heat pump, monitor, temperature change

1 INTRODUCTION

Shenyang is one of the cities which geothermal heat pump systems are widely used in China. More than 400 systems are in use and most of them are groundwater heat pump systems. 417 systems are groundwater source heat pump, and 8 systems are ground-source heat pump.

In order to study temperature changes in different direction and the influence of pumping rate, we select one groundwater heat pump system. Pumping rate, injection rate, soil temperature are monitored in the systems.

1.1 Introduction of the Field

The field of the heat pump system we selected located in the middle of an alluvial fan.

The main formation lithologies include planting soil, medium-coarse sand, gravelly sand, round gravel and clay with gravel. Figure1 shows the geological layers. Aquifer in the site distributed continuously and with high permeability, which is primarily composed of gravelly sand and round gravel and have small change along all direction. The thickness of the aquifer is generally greater than 20m. Groundwater in the aquifer is mainly recharged by the lateral flow of groundwater and the infiltration of atmospheric precipitation. The flow direction of groundwater is mainly from east to west with a hydraulic gradient of 1-2‰. The groundwater runoff condition is very suitable for the exploitation of groundwater-source heat pumps.

1.2 Heat Pump System

The system we selected is a hospital. Heating and cooling area is about 46,000m^2. There are 4 pumping wells in the west side and 8 injection wells in the east side of the hospital. The depths of the wells are 45m. The diameter of all wells is 0.5m. The elevation of strainer position of all wells is between 15-36m. Distance between pumping wells and injection wells is 80m. Distance between each pumping wells is 30m, and also, 30m between each injection wells. The extracted flow rate per well is 100m^3/h. There are about 2 months using one pumping well, and about 3months using two pumping wells. Four injected wells are usually in use, and the other as back-up.

The system works about 150 days in winter and 90 days in summer every year. The annual heating demand is about 2200 KW, and the annual cooling demand is about 2760KW.

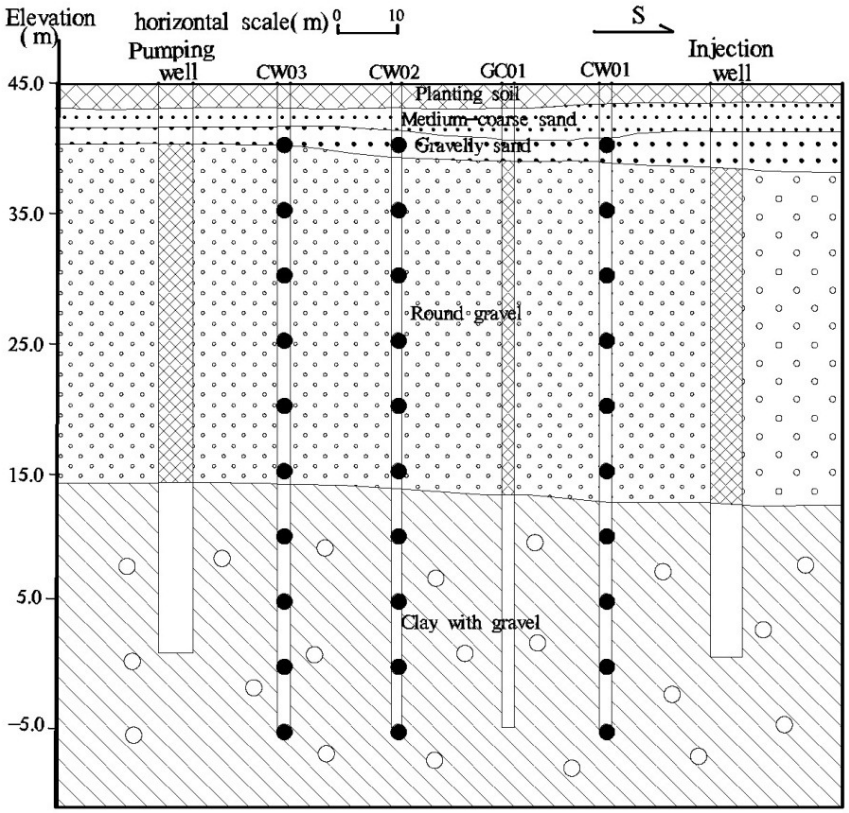

Figure1: profile of the monitoring system

2 ARRANGEMENT FOR MONITORING SYSTEM

3 boreholes（CW01、CW02、CW03）are constructed between pumping wells and injection wells. Each borehole is 50m depth. In each borehole, 10 temperature-measure detectors are put in every 5m depth. During the time that pumping systems are operation, temperature is measured once a day. There is also a well（GC01）in the monitoring system which is used to monitor water level and water quality.

Temperature monitoring lasted more than two years. In this article, we use the dates from November 1, 2011 to October 31, 2012. By analysis the aquifer information, pumping rate and temperature curve, we discuss some questions such as temperature transfer in different aquifer (soil) in geothermal heat pump system, and reasonable distance between pumping and injection wells.

3 ANALYSIS OF MONITORING DATA

3.1 Soil Temperature Changes during Heating Period

In order to analyze the change of soil temperature better, we imagine 1℃ as the region of temperature change. Table1 shows the monitoring time when soil temperature changed 1℃ in different depth. And also, we draw temperature curve in each hole, using the monitoring data during heating period (Figure 2 to Figure 4).

Upper soil temperature is affected by weather and some manmade factor (such as heating pipe line). And also, the ground water level is mostly deeper than 5m. So the monitoring data of 5m is not analyzed here.

Table 1 Monitoring time of temperature changing1□ in different monitoring depth

Monitoring time (day) / depth(m)	CW01	CW02	CW03
-10m	10	10	65
-15m	16	24	109
-20m	14	146	69
-25m	21	-	-
-30m	41	-	-
-35m	26	-	-
-40m	154	-	-
-45m	-	-	-
-50m	-	-	-

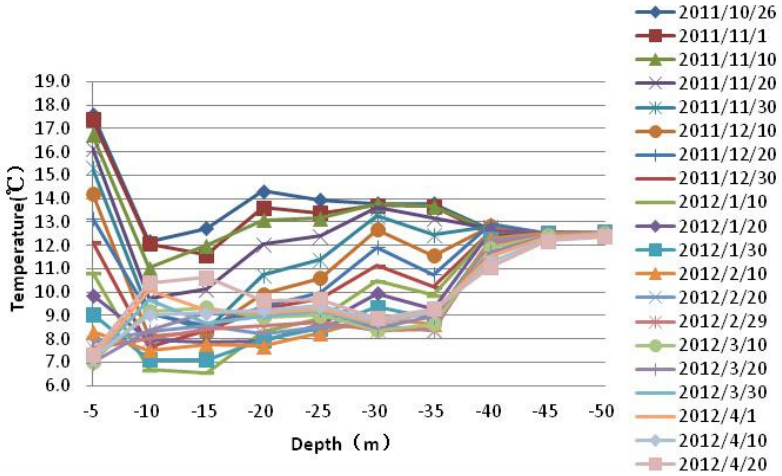

Figure 2: the heating period temperature curve of different depth in CW01

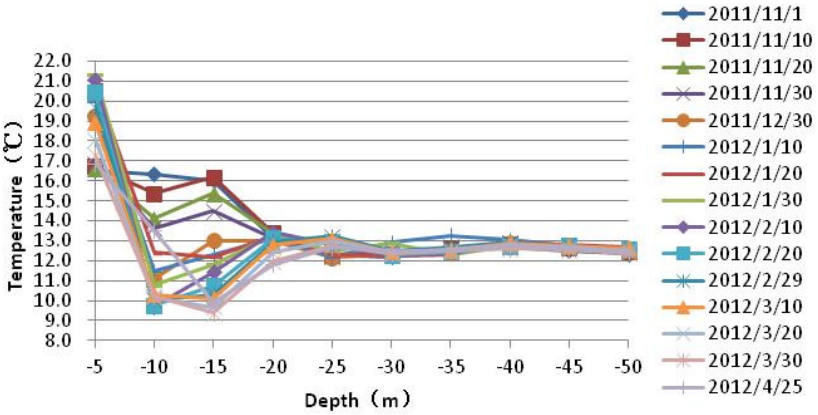

Figure 3: the heating period temperature curve of different depth in CW02

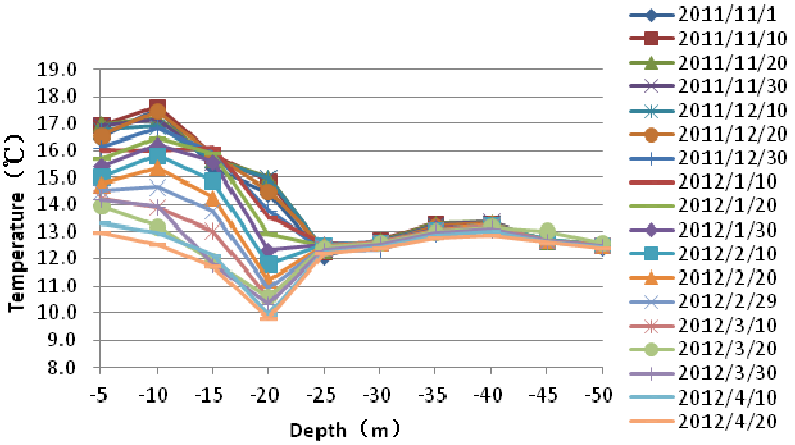

Figure 4: the heating period temperature curve of different depth in CW03

By analyzing monitoring data and temperature curve, we got some opinions as below.

1) In the heat pump site, groundwater flow field is changed. Water moves from the pumping well to the injection well. Monitoring dates show that low temperature water moves from the pumping well to the injection well.

2) Groundwater head gradient changes greatly in the heat pump site. The head gradient is bigger upside. So water flow is more rapid in the upside. The monitoring dates indicated that temperature of 10m depth changes faster than that of deep part.

3) Water pump is located at 25m depth in the pumping well. Low temperature water from upside mixed immediately with normal water. Because water form upside is only about 1℃ different from deep side and the flow rate is less, water temperature changes little out of the well.

4) Groundwater temperature did not change obviously during heating period. This indicated that the distance between pumping wells and injection wells is proper.

3.2 Temperature Changes in Cooling and Recovery Period

We also draw temperature curve in each hole, using the monitoring data during heating period (Fig 5 to Fig 7).

1) Figure 5 and 7 show that groundwater temperature above 25m changes obviously, so the groundwater and temperature transfer is still influenced by groundwater flow field change and groundwater head gradient during cooling and recovery period.

2) Groundwater temperature above 20m is higher than the initial temperature in the final of the recovery period in CW01, and temperature between 20 and 45 meters is still lower than the initial temperature, and temperature between 45 and 50 meters is mostly close to the initial temperature. These show that heat pump system has made slight cold accumulation between 20 and 40 meters around injection wells during the system running and recovery period, and the biggest temperature difference is 2.1℃,happened in 20 and 30 meters, and the temperature difference in 25、35 and 40 meter is 1.6 ℃、1.7℃ and 0.875℃。

3) Groundwater temperature in CW02 is higher than the initial temperature in the recovery period. Possible reasons are that the hot water pipeline near CW02 hole directly affects the monitoring temperature, and it also makes the air humidity in the monitoring well bigger, which makes the monitoring measurement error bigger.

4) Groundwater temperature above 25 meters in CW03 is higher than the initial temperature in the final of the recovery period, and the temperature between 25 and 50 meters is slightly lower than the initial temperature in the final of the recovery period. But according to the monitoring data, the temperature between 25 and 50 meters was not affected by the heat pump system, the reason might be environment temperature floating, and floating range maybe 1 ℃.

In conclusion, if environment temperature floating range is 1℃, the groundwater temperature in the monitoring site is basically in a state of equilibrium though the

whole period. so the distance between pumping wells and injection wells is proper.

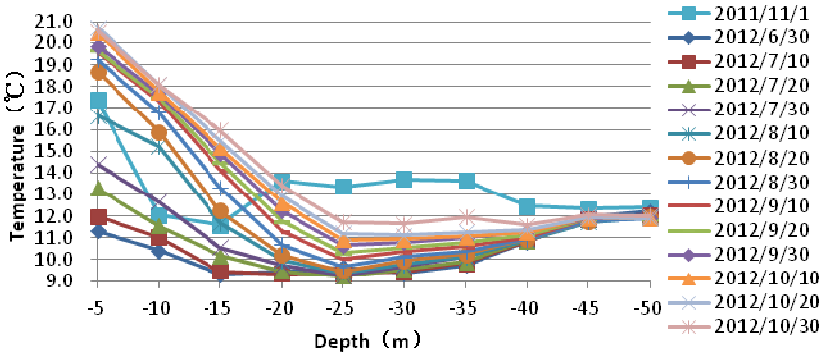

Figure 5: the Cooling and recovery period temperature curve of different depth in CW01

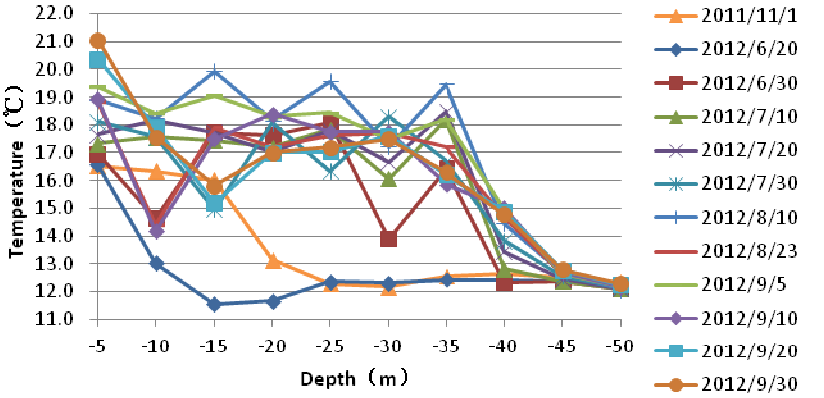

Figure 6: the Cooling period and recovery temperature curve of different depth in CW02

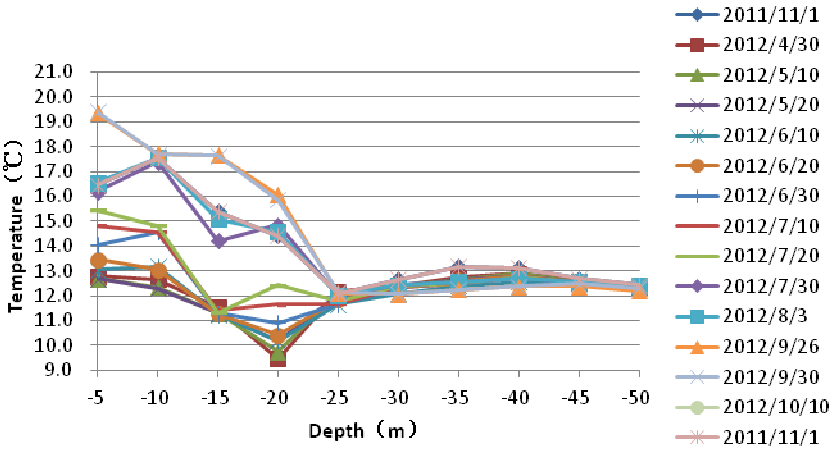

Figure 7: the Cooling period and recovery temperature curve of different depth in CW03

4 CONCLUSION

In this paper, we used the monitoring data obtained from groundwater heat pump

system site to study the migration of groundwater flow field and temperature field, and the results show that:

1) In cold northern regions of China, groundwater heat pump system can work effectively. If the distance between pumping wells and injection wells, groundwater exploitation, etc. is reasonable, groundwater heat pump system doesn't make groundwater temperature significant change.

2) Due to the influence of pumping and injection, groundwater flow field is changed in the heat pump site, and the head gradient is bigger upside. So water flow is more rapid in the upside, and also, the temperature change rapid, but these do not significantly affect the pumping wells temperature

3) In east-northern of china, which the heating period in winter is very longer than cooling in summer, if groundwater heat pump system uses one-sided pumping and the other injection for long term, it may make the temperature lower in deep places around injection wells. It would be better to monitor the groundwater temperature around injection wells to avoid environment problems due to cold accumulation. It is helpful to improve the running efficiency of heat pump to change the pumping wells and injection wells in heating period and cooling period.

5 REFERENCES

Yang Ze, Yu Hui-ming, Du Ji-zhong. (December 2013). “The suitability study of groundwater-source heat pump system in Shenyang Based on the analytic hierarchy process (AHP)” Building energy efficiency [Vol. 41:32] pp.32-35.

Hu Ji-hua, Zhang Yan-jun, etc.(November 2008). “Groundwater Flow Transfixion of Groundwater Source Heat Pump System and Its Influence on Temperature Field” Journal of Jilin University(Earth Science Edition) [Vol.38:992] pp.992-998.

Zhang Yuan-dong, Wei Jia-hua, Wang Ji-yang. (November 2006). “Influence of well pair distance on the changes of geo-temperature field due to aquifer energy extraction” ACTA ENERGIAE SOLARIS SINICA [Vol.27:1163] pp.1163-1167

Du Dan-yan, Hu Ji-hua, Zhang Yan-jun.(August 2008) . “Numerical Simulation of Seepage Flow Field of the Groundwater Source Heat Pump System and Its Influence on the Temperature Field” Building energy efficiency [Vol.36:8] pp.8-12.