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The Study of Environmental Effects of Exploitation and Utilization of Shallow Geothermal Energy in Zhengzhou

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Abstract

Through the survey and monitoring of the existing projects for g shallow geothermal energy exploitation and utilization in Zhengzhou and identification of shallow geothermal energy utilization,the paper studied the effects of the shallow geothermal energy utilization on the geological environment, such as groundwater temperature, groundwater quality, microbial,etc, and prevention measures are put forward.

Keywords: shallow geothermal energy, ground source heat pump,water tempreture,water quality, total bacterial count

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INTRODUCTION

The domestic and foreign scholars carried out a large number of studies about the effects of the shallow geothermal energy exploitation on the geological environment, such as groundwater temperature, groundwater quality, etc. (Couvillion and Coton 1990, Deng et al. 2017, Dobson 1992, Gao 2012, Georgiev et al. 2016, Kılıç and Ravul 2016, Li 2016, Liu et al. 2017, Morais and Tsuha 2016, "Rizzuto 1994, Rybach and Sanner 2006, Wang et al. 2017, Yu 2014, Zhang 2005). These studies provide technical support for reasonable exploitation of geothermal energy and theoretical basis for technology of mining geothermal energy. And it is better promoting the development and large-scale application of shallow geothermal energy. The following will give an introduction of the study area in this paper.

Zhengzhou is the core of the construction of the Zhongyuan urban agglomeration areas and is an experimental city for heating used clean energy of Northern China. During advancing the national central city and the construction of modern metropolis, the application of shallow geothermal energy is developing rapidly. There are more than 200 users including various types of users using ground temperature air condition. The mainly application is ground water source heat pump systems. The operation of system will change the existing groundwater flow field and temperature field, and then have an effect on the effectiveness of energy abstraction system and the groundwater environment (Liu et al. 2017).

Based on the environmental monitoring data of the project for the development and utilization of shallow geothermal energy in Zhengzhou City, the study discusses the influential effect of the development and utilization of shallow geothermal energy on the geological environment form the groundwater temperature, groundwater quality and microbial. The users of shallow geothermal energy in Zhengzhou include schools, administrative bodies, enterprises, institutions, hotels, etc. According to the survey of the manufacturers and users of ground temperature air-conditioning, the users are more than 200 by the end of 2012, and the total area for heating/cooling is about 4 million m^2. In the existing projects for the development and utilization of shallow geothermal energy, there are more than 70% users using ground water source heat pump system, and the total heating /cooling area is about 2.6 million m^2. The number of users using ground water source heat pump system has been increasing since 2011. So far the known heating/cooling area is about 1.4 million m^2.

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The depth and the exploited horizon of the wells for ground temperature air-conditioning will be different because the wells is located on the different part in the landform unit. On the east of Beijing-Guangzhou Railway the landform unit is alluvial plain of Huanghe, the wells are shallow and the exploited horizon are the sand layer in Holocene. Upper Pleistocene and middle Pleistocene. The lithology of the aquifer is middle-fine-sand and fine sand. The thickness of the aquifer is 20-40m, and the groundwater depth is less than 10m. Because of the shallow groundwater level, the pumping water yield is larger, but the recharging effects far from perfect.

The center of the city, with comparatively deep ground water tables, the exploited horizon are the sand layer in upper Pleistocene and middle Pleistocene and late Pleistocene or gravel layer in Neogene. The lithology of the aquifer is middle-fine-sand, fine sand, and sandy gravel. The thickness of the aquifer is 25-50m.the sandstone is formed from sand and sandy gravel by calcite cementation. This situation effect the pumping water volume and recharging water volume.

RESULTS

Effects on Groundwater Temperature

The water temperature of the pumping wells for Ground temperature air-conditioning is about 16～20 ℃. The water of recycling pipeline is 10～15℃ during heating period, the temperature is 2～7℃ lower than the groundwater temperature. The water of recycling pipeline is 18～25℃ during refrigeration period, the temperature is 1～8℃ higher than the groundwater temperature.

According to the groundwater monitoring data of the projects for shallow geothermal energy exploitation and utilization in Zhengzhou Children's Hospital, Lottery center, Meijingtiancheng district and He'nan Branch of China Da Tang, the running of the system has a gradual influence on the groundwater temperature. The results are shown in **Figs. 1 ～ 4**.

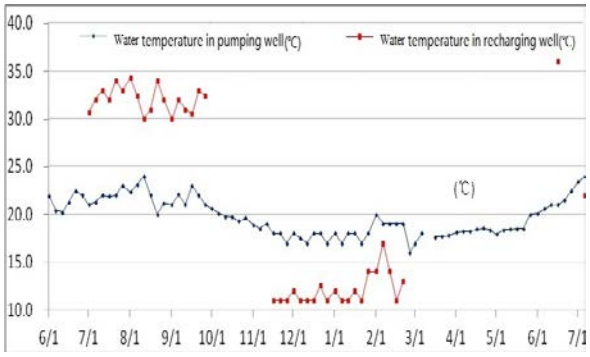

Fig. 1. The groundwater temperature dynamic curve of Ground Temperature Air-conditioning Well in Zhengzhou Children's Hospital

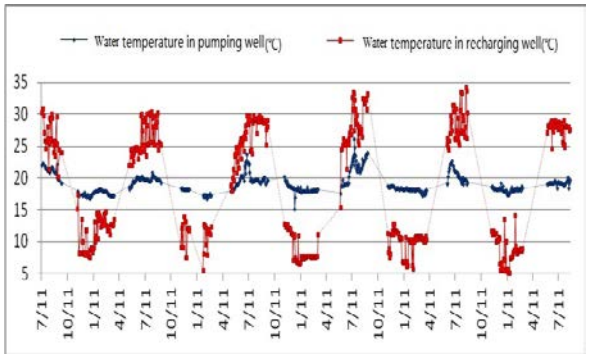

Fig. 2. The groundwater temperature dynamic curve of Ground Temperature Air-conditioning Well in Lottery center

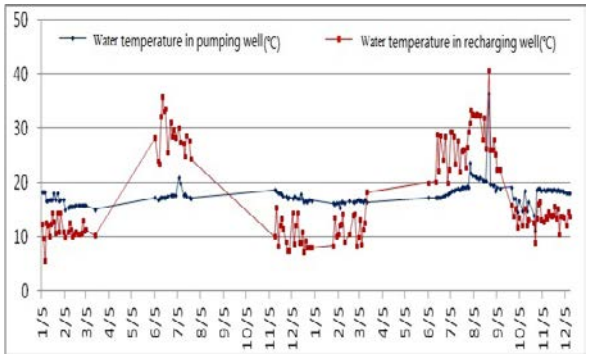

Fig. 3. The groundwater temperature dynamic curve of Ground Temperature Air-conditioning Well in Meijingtiancheng district

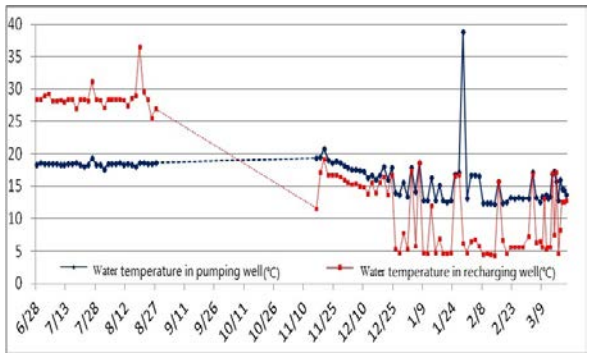

Fig. 4. The groundwater temperature dynamic curve of Ground Temperature Air-conditioning Well in He'nan Branch of China Da Tang

The water temperature of the recharging wells for Ground temperature air-conditioning is about 19~30℃, the highest temperature will be up to 35 ℃ during refrigeration period. The water of recycling pipeline is about 8~15℃ during heating period. The groundwater temperature will be increase during refrigeration period and descend during heating period by the effects of the recharging water temperature. But in a complete time interval including heating period and refrigeration period, the effect of groundwater recharging on groundwater temperature is not obvious.

Effects on Groundwater Quality

Fig. 5 shows that the groundwater quality data comparative analysis of ground temperature air-conditioning well in Zhengzhou Children's Hospital in different periods, including before running the system, during running the system, after running the system and September 2003.

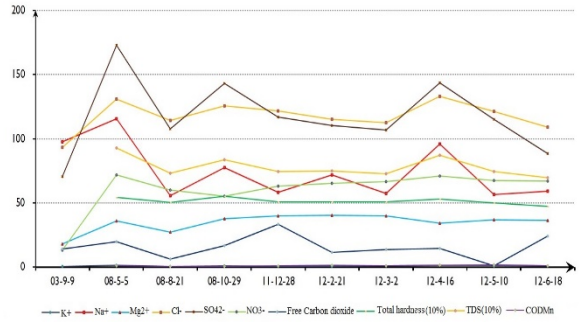

Fig. 5. Groundwater quality data comparative analysis curve of Ground Temperature Air-conditioning Well in Zhengzhou Children's Hospital in different periods

The comparative analysis on the groundwater data in different periods shows that most of the content has no obvious change. The content of Na^+, Mg^{2+}, Cl^-, SO_4^{2-}, HCO_3^-, NO_3^- has slight changes with the high water period and the low water period. The trend variation is not detected.

Effects on Total Bacteria in Groundwater

The microbiological monitoring is carried out in the water samples of during the projects running in Zhengzhou Children's Hospital and Mineral Research and Development Centre.

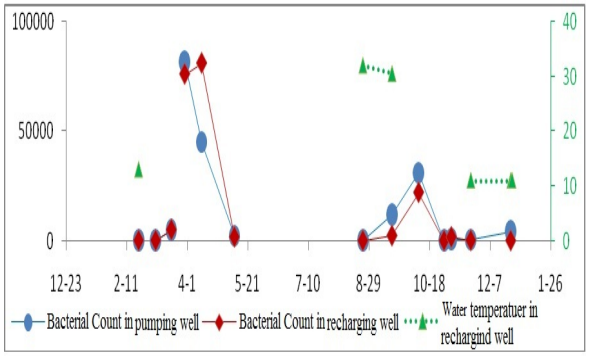

Fig. 6. The bacteria content comparison curve in the pumping wells and the recharging wells during different periods in Zhengzhou Children's Hospital

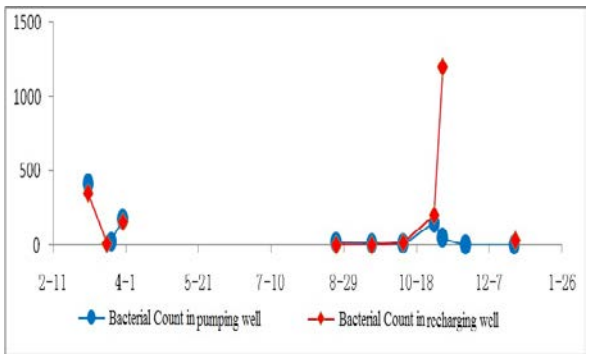

Fig. 7. The bacteria content comparison curve in the pumping wells and the recharging wells during different periods in Mineral Research and Development Centre

The changes of bacterial count shows that groundwater recharging have significant influence on the total bacterial count during the running of groundwater source heat pump system. The bacterial count in recharging wells is consistent with that in the pumping wells. And generally the bacterial count in recharging wells is less than that in pumping wells. That maybe because of the water temperature in the running of heat pump unit change the microbial environment and affect the microbial activities. After recharging, groundwater temperature is gradual returning to normal and the microbial environment is brought to its original state. This shows that the geological conditions

can regulate the microbial environment (Zheng et al. 2005).

Comprehensive Prevention and Treatment

According to the monitoring study on the shallow geothermal energy exploitation and utilization in Zhengzhou, the long-time running of groundwater source heat pump has different influence on groundwater temperature, groundwater quality and microbial. It is necessary to take the following comprehensive prevention and treatment (Gao et al. 2009).

1. Rational Control of pattern well spacing and the exploited horizon. According to the hydrogeological condition, the layout of pumping wells is reasonable established, the exploited horizon is reasonable identied, aquitard and limitation extraction layer should be avoided. The continual decline in groundwater level can be prevented and the environmental geological problems, such as ground subsidence and Surface collapse, etc., will be prevented.

2. Strict control of the volume, the temperature and quality of the recharging water. The recharging must be controlled in the same layers and the water quality and temperature should be constantly monitoring to ensure the minimizing effects of recharging water on the geological environment.

CONCLUSION

The users are more than 200 by the end of 2012, and the total area for heating/cooling is about 4 million m2 in Zhengzhou. According to the groundwater monitoring data of the projects for shallow geothermal energy exploitation and utilization in Zhengzhou Children's Hospital, Lottery center, Meijingtiancheng district and He'nan Branch of China Da Tang, the running of the system has a gradual influence on the groundwater temperature. Groundwater quality has slight changes with the high water period and the low water period. The trend variation is not detected. The bacterial count in recharging wells is consistent with that in the pumping wells during the running of groundwater source heat pump system. After recharging, groundwater temperature is gradual returning to normal and the microbial environment is brought to its original state.

LIMITATION

This paper is mainly including part of Zhengzhou and can not be representative of the whole Zhengzhou. So strengthening long-term monitoring of each stations and building the monitoring net of shallow geothermal energy in Zhengzhou can provides more reliable foundation for the effect study of development and utilization of shallow geothermal energy on geological environment

Exploitation and utilization level of shallow geothermal energy is pathetic. The system managers is bad in professional standards and poor in energy saving consciousness. There are so many problems in design, construction and management of the monitoring system that can not get the real-time monitoring data. Moreover, the lack popularity for shallow geothermal energy technologies can not make the public realized.

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