Geothermal Water For Multiple Purposes In Beijing

WANG SUMEI[1] and XIE GUIYIN[2]

[1]*Beijing Institute of Geological Engineering and Exploration, Beijing, P. R. China;*
No. 90, Beiwalu St.Haidian District, Beijing, 100037 P.R.China E-mail: wangsumei2003@sina.com
[2] *Geothermal Management Department, Beijing, P. R. China;*
No. 4, Nanweilu St.Xuanwu District, Beijing, P.R.China

Abstract
Beijing is abundant in low-temperature geothermal groundwater, which is mainly used for multiple purposes as bathing, space heating, medical treatments, plantation in greenhouses, aquatic cultivation, potable mineral water, industrial technology.

In history, about 400-500 years ago people applied hot-spring water in Xiaotangshan, Changping County of Beijing. In the Southeastern Urban, development and utilization of geothermal groundwater for multiple purposes started in the early 1970s. Gradually, people in these areas change the portion of the former energy sources, improve the local environment, provide medical healthy services to the communities, and finally make social accomplishment and economic benefits.

To administer the geothermal energy, Beijing Government issued <<Temporary Regulations For Strengthening Management Of The Geothermal Groundwater>> in 1985, which improves the utilization and scientific research of the geothermal groundwater in the area.

As a conclusion, multi-utilization of the geothermal groundwater has been an important attributing part to the progress of the city in both economic development and social service.

Keywords
Beijing, Geothermal Water, Multiple, Purposes

Introduction

There are rich geothermal resources in Beijing. The area of geothermal fields is about 309 km^2. The developing & utilizing of the geothermal water mainly focused in four regions: North Yanqing Geothermal Region, Wenquan-Shahe-Xiaotangshan Geothermal Region, Shunyi-Urban-Liangxiang Geothermal Region, and Caiyu-Xiji-Fengheying Geothermal Region.

There are two types of geothermal groundwater reserving in the city. One is outcropped springs in the interface faults by granites and carbonatites in Yanshang Period, scattered over Fuyukou, Xiaotangshan, WenquanVillage, etc. The reservoir layer is shallow. The other is fissure and karst water reserved in sedimentary basins. The reservoir layer is deep, constituted by mid-upper Proterozoic carbonatites, covered by middle-Cenozoic volcanic rocks and clastic deposits. From northwest to southeast, four geothermal regions could be defined as following:

North Yanqing Geothermal Region The region is located in Yangqing Basin, the area is 170 km^2. The heat reservoir layer is low-Proterozoic rock. Fuoyukou Spring is a natural spring with a temperature of 42℃, and the artesian quantity is 60 m^3/d.

Wenquan-Shahe-Xiaotangshan Geothermal Region The region includes Shahe Town and Xiaotangshan geothermal fields. The area of Shahe Town Field is 60 km^2, the water temperature is 26℃-35℃. The heat reservoir layer is shallow with depth of no more than 600-meter, constituted by carbonatites. The explored area of Xiaotangshan Field is 20 km^2, the water temperature is 35℃-64℃. The heat reservoir layer is constituted by carbonatites in Tieling Group and Wumishan Group, Jixian System (Chinese groups and subsystems in Cambrian system). There are 37 boreholes with the depth of 350-1,200 meter, single well withdrawal is 50-70 m^3/h.

Shunyi-Urban-Liangxiang Geothermal Region The region includes Southeast Urban and Liangxiang geothermal fields. The explored area of Southeast Urban Field is 120 km^2, the water temperature is 38.5-70℃. The heat reservoir layer is constituted by carbonatites in Tieling Group and Wumishan Group, Jixian System. There are 65 boreholes with the depth of 650-2,600.5 meter, single well withdrawal is 1,000-2,240 m^3/d. The area of Liangxiang Fieldis 5 km^2, the water temperature is 36℃-42℃. The heat reservoir layer is constituted by carbonatites in Tieling Group and Wumishan Group, Jixian System. There are 10 boreholes with the depth of 300-1,350 meter, single well withdrawal is 800-1,200 m^3/d.

Caiyu-Xiji-Fengheying Geothermal Region The northwest boundary of the region is next to Daxing convex. The area is 2,400 km2, the average water temperature is 53℃. The heat reservoir layer is constituted by carbonatites in Ordovician System. There is a borehole in Fengheyin, Daxing County with the depth of 2,270 meter, the artesian quantity is 50 m^3/d.

Experimental

In Beijing plain, there has been a 400-500 years history of developing and utilizing geothermal resources. There have been 125 geothermal wells in Beijing by 1998, including the natural thermal springs. Some geothermal wells are under construction. In 2008, the Olympic Games will be held in Beijing, and Beijing Municipal has carried on a project for “Green Olympics in 2008”. In Beijing, the geothermal groundwater is mainly used for space-heating, bathing, medical treatment, aquatic cultivation,

plantation in greenhouses, bottling or scanning mineral spring water for drinking, and for industrial technology.

I. Space heating

The hot-water reservoir is mainly presented in the carbonate rocks of Wumishan Group, the water temperature in which is above 50℃, with HCO3-SO4-Na type, pH value is 7.2-7.9. The burial depth of the reservoir layer is more than 1,000 meter, the highest water temperature in which is 64℃.

In Beijing, the heating period is from November to the next March (150 days). The geothermal space-heating system began since 1975, and has been well developed recently. At the present, there are 29 institutions installed with the geothermal space-heating system, 30 geothermal wells are used, which makes up 32% of the total. annual consumption is 4,000,000 m^3, which makes up 47% of the total. Building areas of the city using geothermal heating are 326,000 m^2 totally.

Geothermal heating systems are mainly focused on the Southeast Urban Geothermal Field and Xiaotangshan Geothermal Field. In Xiaotangshan Geothermal Field, there are 12 organizations using geothermal heating (Table 4). The heating area is 142,000 m^2, and 14 geothermal wells are used. The reservoir layer is shallow, the water quantity is large, and the quality is good. The highest temperature is 64℃. When the outside temperature is -9℃ in winter, the indoors temperature using geothermal heating keeps about 16℃.

In South-eastern Urban Geothermal Field, there are 17 institutions using geothermal heating, 14 geothermal wells are used, 184,000 m^2 area of heating buildings areas, which are mainly located in Yongdingmen and Tuanjiehu from south to north.

No.	Institution using space heating	Temperature (℃)	Annual consumption (m^3)	Heating area (m^2)
1	TPMC Institute	58	22	17,000
2	BTB Sanatorium	64	16	15,000
3	ES School	56	7	7,791
4	Xiaotangshan Town Gove.	42		5,000
5	Mash Prod. Factory	51	10	7,255
6	Air Reception	50	8	3,000
7	Aquatic Farm, Beijing	44	50	1,510
8	No.2 Social Welfare	42	6	18,000
9	Beijing Birds Company	43	11	3,046
10	Special Vegetable Base	47	8	---
11	Xiaotangshan Nursery	59	8	7,040
12	Xiaotangshan Recu. Hosp.	53	90	51,049
13	Xichang Sanatorium	53	20	7,000

Total	256	142,691

Table 1 Institutions using space heating system in Xiaotangshan Geothermal Field

II. Bathing using geothermal water.

Geothermal bathing is rather popular in Beijing. There are 64 geothermal wells for bathing, 70% of all the developing and utilizing wells in Beijing (92). There are 61 organizations using geothermal water for bathing, mainly located in Southeastern Urban, Xiaotangshan and Liangxiang. Bathing pools are 15,000 m^2, 4,410 separated rooms, there are 80,000 persons take bath in these places every day. The water quantity used for bath makes up 40% of the total annual quantity.

In Beijing, there are 6 commercial bathing pools. In the organizations, there are 18 pools open to society.

Record.	Geo. No.	Quantity (m^3 /day)	People (person/day)	Spray number	Room area (m^2)
1	Geo. 34	368	1000	30	110
2	Geo. 2	150	1000	66	100
3	Geo. 39	250	2500	180	600
4	Geo. 47	300	300	37	180
5	Geo. 35	430	1000	306	80
6	Geo. 22	480	4000	184	1200
7	Tuan. 5	210	500	43	400
8	Geo. 9	200	1500	66	199.5
9	Geo. 41	1348	15000	146	652
10	Geo. 42	300	2200	40	230
11	Geo.Rol.	400	1200	38	54.2
12	Geo. 21	300	2500	67	500
13	Geo. 37	400	3500	103	750
14	Geo.	250	2600	73	251
15	Geo. 17	450	4500	96	180
16	Chann.1	186	150	33	66
17	Geo. 31	400	1200	140	800
18	--	500	1100	820	280
Total		6972	45850	6957	2648

Tab. 2 Open pools to society

C. Medical treatment

There is a long medical treatment history using geothermal water in Beijing. Xiaotangshan spring has a history of 400-500 years. In《Raoshangtangwei Annals》, there is a poem recorded the hot springs in Xiaotangshan, from which we can see people's

attention to Xiaotangshan hot springs in Ming Dynasty. 《United Year-book in Daqing Dynasty》, there are records "When Qianlong built up the palaces: they set up bathing pools, and move Dragon Temple to east of Tangshan. Nearby the spring, it is the visiting palace, north of the front palace, a Royal back yard was established, the emperor and empress often came here and took bath ".

In 1958, "Xiaotangshan Sanatorium, Beijing" was setup, which is the first multicipal spring convalescence hospital in Beijing, and the famous spring recuperation center in China. From its establilishment, there are more than ten thousand patients with various illness, receive medical treatment and return to their former positions.

Springs in Xiaotangshan are suitable for medical treatment. The water temperature is about 50℃**,** three withdrawal wells, quantity is 2,000-2,5000 m^3/day. The heat reservoir layer is carbonate rock of Wumishan Group, Jixian System. In the geothermal water, there are compositions as K, Na, Ca, Mg, Si and F etc., and a little radioactive elements as Rn and Ra. The general mineralization is less than 0.5 gram/liter, the water type is HCO_3-Na-Ca type.

Besides, there are 6 geothermal sanatoria, which own seven geothermal wells in Beijing. There is one in the urban, called "China Recuperation Research Center" in Majiapu; three in Xiaotangshan, they are: *a*. "Xiaotangshan recuperation Hospital", *b*. "Xichang Sanatorium", *c*. "Xiaotangshan Telecommunication Sanatorium, Beijing"; one sanatorium in Lisui Town, Shunyi County, called "Cataclasis Hospital of Chaobai River". Totally, there are 1600 beds.

In Chinese medical theory, hot spring treatment to human's body is to change the outside stimulant to human's body, with media of water, cause the function changement of inside organs through the adjustment of nerve and body-fluid. There are three substantial elements: temperature, mechanics and chemistry.

1. Temperature effects Hot spring bath below surface temperature of body may cause excitenment to human's sympathetic nerve system, blood vessel of skin shrinks, pulse slows down, pulsation of heart blood reduces, blood pressure rises, blood sugar increases. Hot water bathing may cause sub-sympathetic nerve excited, skin blood vessel extend, pulse fast, heart blood pulsation rises, blood pressure declines, skin temperature rises, muscle convulsion releases, metabolism is improved, blood sugar is reduced. When the difference between hot water and body temperature is larger, the effect of stimulant is obvious

2. Mechanics Effects It's mainly water's buoyancy, pressure and wallop. With test, man with 75 kg weight would charge to 7.5 kg in freshwater. Therefore, spring bath could reduce the burdensome of movement organ is good for recuperation of arthrosis obstacle illness.

3. Chemistry Effects Chemical material in hot-spring water, may stimulate nerve-end of human's skin, cause nervous reflection, so that, it can treat some medical illness. Eg. H_2S could treat skin illness; water with fluorine could treat psoriasis illness, Ra has the abirritation, ataractic and antiphlogistic effects, Rn could improve body metabolize, increase immunity ability.

D. Aquatic cultivation

Aquatic cultivation using geothermal ground water mainly focuses in Xiaotangshan area, Changping County. There are two aquatic farms, one is Beijing Aquatic Company; the other is Husbandry and Aquatic Department in Changping county. 8 geothermal wells are in operation, annual water-usage quantity is about 1,200,000 m^3, 13-14% of total geothermal water-usage quatity in Beijing. The cultivation surface area is 207 mu (13.8 hectare) in the two aquatic farms, there are 200,000 kg/year fishes, which includes Nile crucians, carps, grass carps etc, recent eels, turtles, shrimps bull frog, etc.

From the end of 1970s, aquatic cultivation using geothermal water has begin in Beijing, the areas of water surface extend every year, species have been increased gradually, the economic and social effects have become greater. For instance, in Changping County Aquatic cultivation, the annual production of Nile crucian is 40,000 kg, the income is RMB 60,000, the annual production of Nile crucian is 100,000 kg, the income is RMB 800,000, the economic benefit is remarkable. Meanwhile, quality fresh fishes are provided in the Capital market, which flourishes the market, get good social effects.

E. Plantation in greenhouses

In 1983, Geothermal Development Company in Xiaotangshan began plantation in greenhouses using geothermal resources. The Main plantations are special vegetables: cauliflowers, parsley etc, totally more than 60 species. There are 50 mu (3.33 hectare) geothermal greenhouses, 3 geothermal wells with 50-53 water temperature. The vegetables mainly supply for Foreign Hotels. The annual production of the vegetables is 500,000 kg, the annual income is 1,200,000/year. Therefore, plantation in greenhouses causes good economic and social effects.

In 1986, Beijing Agriculture University carried on four-season plantation in greenhouses using geothermal greenhouses, with new techniques in water, fertilizer, seeds, soil and management etc. The scientific plantation remarkably increases the products quantity. Before 1986, the average production quantity had been 120-750 kg/mu (1/15 hectare), after 1988, the production has been raised to 2290-5300 kg/mu (1/15 hectare).

In 1987,Changping Agriculture Bureau established a special vegetable plantation base in Xiaotangshan area, they have planted European celery and flowers using a geothermal well with 47℃temperature water, the area of the greenhouses is 11 mu (0.73 hectare).

In Beijing, there have been 70.5 mu (4.7 hectare) geothermal greenhouses by 1998, mainly scattered over the Xiaotangshan area. The annual water quantity being used is 500,000 m^3, about 6% of the total in Beijing City.

Lisin geothermal field in Shunyi County has a profound potentiality in the development of geothermal greenhouses.

F. Mineral Water for Drinking

From 1980's, people have begun to pay more attention to mineral spring water for drinking because of its good social and economic effects. And from then on, Beijing geothermal ground water has begun to be developed to mineral spring water

for drinking. At present, through appraisal of agencies at the ministrial and cities level), a mineral spring water factory has been built up in Yongdingmenwai Grain Storehouse and Wenquan Bath-hall in Chaoyang District. In 1989, the Factory began to produce mineral spring water for drinking, product quantity is 35 m^3/day. (Consuming 105 m^3/day). The water has been sold in civil markets, and the economic and social effects are remarkable.

"Kesai" is a name of the mineral spring water produced by Yongdingmenwai Grain Storehouse, the product quantity is 20 m^3/day. "Shiling" is an other name of the mineral spring water produced by Chaoyang Wenquan Bath Hall, the product quantity is 15 m^3/day.

G. Usage in industrial production technology

In Beijing Electric Image Tube Factory, a 50℃ geothermal well is used for heating. Part of the discharged wastewater is purified for manufacturing electric-image tubes, which provides a new way for industrial utilization of geothermal water, and has accumulated a new experience of saving energy.

Results

"Utilization Technology and Research of Geothermal Ground Water in Beijing" is a purposive project in Beijing Scientific and Technical Committee. Beijing geothermal Management Department are organizing the cooperation of various departments to solve problems to improve the developing level & utilizing grade of the development and multiple purposes utilizations of geothermal water in Beijing.

To administer the geothermal energy, Beijing Government issued <<Temporary Regulations For Strengthening Management Of The Geothermal Groundwater>> in 1985, which improves the utilization and scientific research of the geothermal groundwater in the area.

Discussion

There have been some issues under discussion: There is no peak-regulation equipment in the low-temperature geothermal space heating system, the heat supply is not enough in peak-load period**,** as a result, the indoor temperature indoors in some organizations is rather low (about 14℃). At present, because of corrosion problems some geothermal systems were abandoned. Effective measure should be taken accordingly.

Conclusions

In Beijing, the multiple purposes of geothermal water includes space-heating, bathing, medical treatment, aquatic cultivation, plantation in greenhouses, bottling or scanning mineral spring water for drinking, and for industrial technology. There are some charactoristics of the development and utilization of the energy. Firstly, it has a history of 400-500 years on developing and utilizing geothermal resources. Secondly, the enery reserve is abundant. At last, remarkable effects in economics and society during the development and utilization have been fulfilled.

References

[1] Wang Sumei and Zhang Daofu, *Comprehensive Utilization of Geothermal Resources in Beijing*. Geological Publishing House, Beijing (1996)

[2] Yang Zhanyuan, Ye Chao and Wang Sumei,. *Groundwater Supply in Beijing*. Geological Publishing House, Beijing (1996)