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Thermal Spa "Banja Kanjiza" - an Example of Successful Utilization of Geothermal Energy

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ABSTRACT

Thermal spa "Banja Kanjiza" is situated in the northern part of Serbia and represents an example of successful utilization of thermal and mineral water. The first artesian well which produced water with temperature of 27.5 ºC from aquifer at a depth of 270 m had been drilled in 1908, while the thermal spa was founded five years later. Medical treatment included bathing and drinking water under medical supervision.

Serious utilization of geothermal energy started when the first deep well was drilled in 1977. In the course of time - by developing of thermal spa - there appeared requirements for increased and continuous supply of warm water for balneology as well as thermal energy for space heating and domestic warm water. In order to fulfill that demand two more wells were drilled (in 1983 and 1996).

The wells extracted water from the Upper Miocene and Lower Pliocene aquifers at different depths which are composed of sand and sandstone layers. Flow rates by well differ from 2.5 to 17.5 l/s with outgoing temperatures in range of 45 to 72 ºC. Production of thermal water depends on type of use and time of the year.

Today thermal water is used in balneology, in outdoor and indoor swimming pools, as domestic warm water and for space heating and cooling. Total installed capacity is around 3.2 MW.

The paper will give more details about geological research, quality of water, types of use and environmental effects which are caused by utilization of renewable source of energy.

1. INTRODUCTION

Thermal spa "Banja Kanjiza" is located 200 km north of Belgrade. The first artesian well, known as "The Miraculous Well", with depth of 270 m was drilled in 1908. The water of this well had yellowish color and temperature of 27.5 ºC. The first water analysis had been carried out in the Royal Chemistry Institute in Budapest in 1910. Thermal spa "Artesian Bath" was founded five years later, in 1913. The healing was carried out by bathing and drinking water under the supervision of the doctor. The water had been bottled in 1 l and 0, 5 l bottles with a label "Water of the Miraculous Well - Old Kanjiza".

For more than nine decades, "Banja Kanjiza" has developed into a modern institution for rehabilitation which is equipped with the most modern equipments for Physical Medicine and Medical Rehabilitation (Figure 1.).

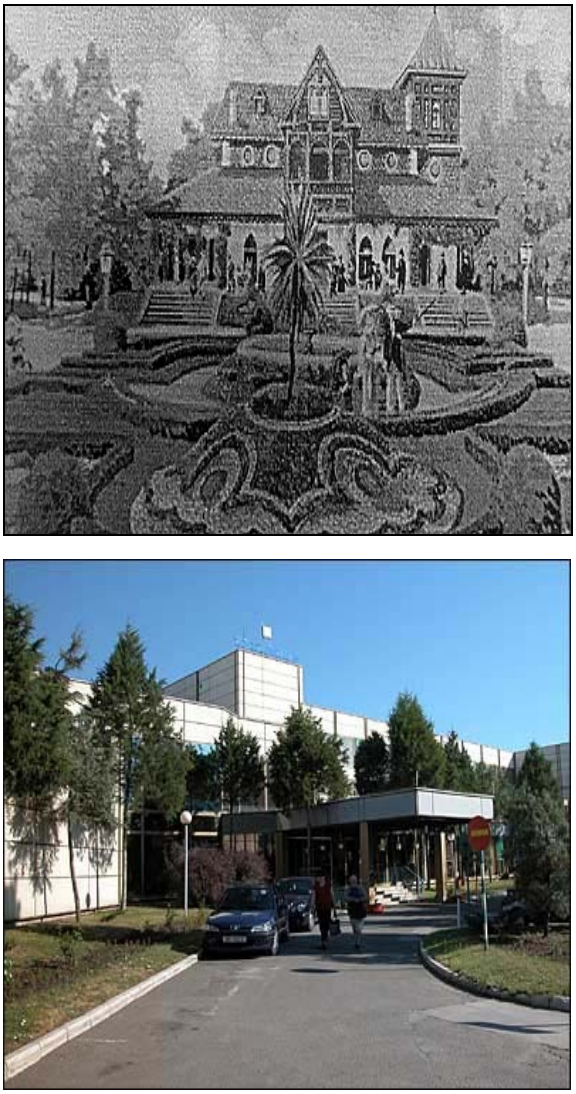

Figure 1. Thermal spa "Banja Kanjiza" - "Artesian Bath" in 1913 (above) and The Specialized Institution for Rehabilitation, hotel "Aquamarin" in 2004 (down)

The hotels "Aquamarin" and "Abella" give hospitality for those who need rest, preventive recovery and medical rehabilitation, as well as the comforts of the curing water and mud.

2. HYDROGEOLOGICAL RESEARCH

Hydrogeological research started in the middle of 70's in order to determine possibility of utilization of geothermal energy in thermal spa.

The first deep artesian well Kz-1/H which purpose was to find out aquifers that produce thermal water suitable for balneology was drilled in 1977. Two water producing

intervals at depth of 660-750 m were selected for screening. Selection was made on the base of analysis both previous geological data and data which were provided by drilling, core sampling and interpretation of logs. The well Kz-1/H produces water from two sandy layers which age is described as Lower Paludin. Artesian well flow is 2.5 l/s with temperature of 45 ºC.

Enlargement of spa facilities caused requirements for increased supply of water and new geothermal well was drilled in 1983. Main task of drilling a new well was to define existence and hydrogeological characteristics of water productive intervals from Kz-1/H in southeastern part of terrain. After drilling it was concluded that productive layers with good flow rate and higher water temperature could have been obtained at greater depth from layers of Upper Pontian age.

Figure 2. Location of wells - Kz-2/H (above) and Kz-3/H (down)

Two layers with good hydrodynamic parameters represented by weakly consolidated sandstone were penetrated at depth of 900-970 m. Artesian well flow was 11 l/s with temperature of 65 ºC. Considering the good results provided by well Kz-2/H utilization of thermal water has been expanded to space heating and as domestic warm water.

In the course of time - during the exploitation period - flow rate of well Kz-2/H was decreasing so the third well Kz-3/H was drilled in 1996. (Figure 2.). This well should have provided data on deeper potential productive zones then those ones screened by Kz-2/H. The target was set to develop geothermal well producing water with higher temperature and similar water quality as well as unburden productive intervals from Kz-2/H.

Four weakly consolidated sandstone layers of Upper Pontian age at depth of 1000-1100 m were screened by well Kz-3/H. Well produces about 17.5 l/s with outgoing temperature of 72 ºC. Downhole pump is installed to lift water to the surface and the system is in production during entire year.

The step drawdown test was conducted in 2003 in order to solve the problem of decreasing flow rate in well Kz-2/H. Maximum artesian well flow was 4.5 l/s. Since the scale and sand were found in degasser it was concluded that technical conditions in well had caused decreasing of flow rate. Further works in well will be to establish facts about technical state of well construction, remove scale and sand and install downhole pump. It is expected to regain flow rate in previous value after this operations.

Possible effects of production from geothermal well Kz-3/H on Kz-2/H are also analyzed. On the base of logs from all three geothermal wells the screened water productive zones can be correlated in every well (Figure 3.).

Due to small distance between Kz-1/H and Kz-3/H logs and lithologic profiles from these two wells practically have identical congruence of penetrated layers concerning thickness and lithologic description. Logs from well Kz-2/H have similar response on applied methods of logging.

Significant differences of position of productive zones between wells Kz-1/H and Kz-3/H on one side and Kz-2/H on the other side, since the distance is only 650 m, is probably effect of faulting within younger stratigrafic units. This fault is shown on time-section Mz1498 (Figure 4.). Fault existing in northeast-southwest direction is confirmed by interpretation of seismic survey which was carried out for purpose of oil exploration in wider region. North side of fault is moved down for 100 m relative to south side and that can be seen on the logs from wells too. It was concluded that wells Kz-2/H and Kz-3/H screened same layers (in stratigrafic and litological meaning) which are divided in two different hydrodynamic complexes by fault.

Temperature changing with increasing the depth is measured during the hydrodynamic measurements in the wells Kz-1/H and Kz-3/H both in the static and dynamic the conditions. Geothermal gradient of 5.6 ºC/100 m is calculated on the base of measured data in the static conditions. This value is same for Lower Paludin and Upper Pontian sediments and greater then average one for this part of Pannonian basin.

3. QUALITY OF THERMAL WATER

Water from all three geothermal wells is defined as sodium-hydrocarbonate type of water (Figure 5.). Mineralization depends on depth of water productive zones and varies in range from 2.08 g/l (Kz-1/H) up to 4.35 g/l (Kz-3/H). Chemical compositions of waters are constant during the period of exploitation.

Waters from each well contain certain amount of dissolved gasses with dominant content of methane. Gas-water ratios range between 1.00 - 1.52 m^3_g/ m^3_w and depend on flow

rate of the wells. Hardness is very low due to low content of calcium and magnesium in water and no significant problems with scaling in wells and hydrothermal system for water are recorded so far (except well Kz-2/H).

The thermal water for medical treatments falls in the category of sodium, hydrocarbonate, iodine, bromine, sulfurous, alkali and hyperthermic water (Table 1.). Water is used in the treatments of rheumatic diseases caused by injuring of the bone joint apparatuses, as well as for recreation.

Table 1. Chemical composition of water

Well	**Kz-1/H**	**Kz-2/H**	**Kz-3/H**
Kation (mg/l)			
Sodium, Na	583.00	1037.00	1067.00
Potassium, K	4.20	9.30	9.30
Calcium, Ca	7.10	6.70	2.80
Magnesium, Mg	3.10	2.30	1.60
Iron, Fe	0.19	0.14	0.52
Strontium, Sr	0.05	0.17	0.23
Anion (mg/l)			
Chlorine, Cl	78.70	51.1	109.90
Hydrocarbonates, HCO_3	1565.90	2918.90	2878.60
Carbonates, CO_3	0.00	0.00	0.00
Sulphates, SO_4	0.00	0.00	2.50
Nitrates, NO_3	0.20	0.37	0.47
Nitrites, NO_2	0.03	0.004	0.06
Iodine, J	0.90	8.76	1.55
Bromine, Br	0	5.71	0.91
Boron, B	2.70	7.02	8.30
Fluorine, F	2.70	1.23	1.25

4. UTILIZATION OF THERMAL WATER

Utilization of geothermal energy at spa “Banja Kanjiza” is based on direct heat utilization. The spa complex consists of

- hotel of old Spa, “Abella” with accommodation wing built in 1985 (with installed capacity of 450 kW for radiator heating),
- hotel “Aquamarin” with rehabilitation block built in 1980 (with installed capacity of 502 kW for radiator and floor heating and 1780 kW for air heating) and
- apartment building "Ana" built in 2003 (with installed capacity of 245 kW for air heating).

During the building of hotel “Aquamarin”, it was designed that the thermoenergy block would work with conventional heating boiler rooms and liquid fuel operated boilers. After drilling and completion of well Kz-2/H liquid fuel was successfully replaced with utilization of geothermal energy.

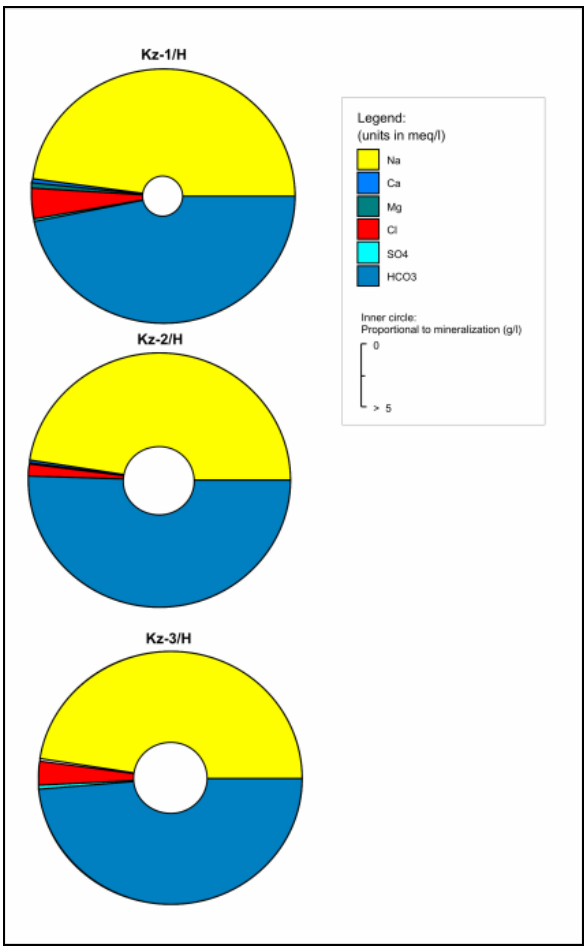

Figure 5. Pie charts of chemical composition

During 1988/1989 the thermotechnical installation at the “Aquamarin” was reconstructed and exchange thermal water station with two plate power exchangers of 1050 kW and 600 kW was built.

The exchange station installation is shown in Figure 6. Thermal water is pumped from wells to exchange heat station and after extracting heat into geothermal water tank. Cooled water from tank is distributed to medical block for treatments, swimming pool and system for domestic warm water. Required water temperatures for these applications are accomplished by mixing cooled water from tank and fresh water from wells. After reconstruction of thermoenergy block the heating boilers can be replaced with thermal water for extern temperature condition up to -5 °C. When the temperature drops below -5 °C, the heating boilers operate only the radiator heating of those rooms that are not provided with air heating.

Utilization of geothermal source was based primarily on production from well Kz-2/H until 1998. Due to decreasing of artesian flow rate and some technical problems this well was fully replaced by well Kz-3/H in 2000. After introduction well Kz-3/H into production, the hydrothermal system for thermal water was reconstructed thus allowing the supply with thermal water from each individual well or mixing thermal waters of different temperatures depending on the current demands of consumer.

Thermal water from well Kz-1/H is used for medical treatments, outdoor and indoor swimming pools during summer period. During winter period water is used for space heating of a greenhouse located in close vicinity of

spa. The greenhouse is designed for growing flowers and covers an area of 0.5 ha.

For the future development of utilization of geothermal energy management is planning expansion of accommodation capacities (the third floor superstructure of the hotel "Aquamarin"), building a new complex of outdoor swimming pools "Aquapark" and realization of the project for fish farming.

Total capacity of geothermal source is 3200 kW of which 75 % is capacity of well Kz-3/H. The capacity of geothermal source is expected to increase up to 4300 kW after conducting workover operations and installing a pump in well Kz-2/H.

Installed heating system produces 4.16 GWh of CO_2 emission-free thermal energy annually and substitutes more than 495 000 m^3 of natural gas. This is very important ecological effect since the spa is located in very pleasant environmental surrounding.

5. CONCLUSION

Utilization of geothermal energy at spa "Banja Kanjiza" is based on direct heat utilization. The mayor part of thermal water consumption goes to space heating and domestic warm water, while the less part is used for medical treatments and recreation. Space heating is also provided for greenhouse nearby spa.

Thermal spa "Banja Kanjiza" represents rare example of multipurpose utilization of geothermal energy in Serbia and provides more efficient way of exploitation of geothermal resource and relatively steady production from wells during the year.

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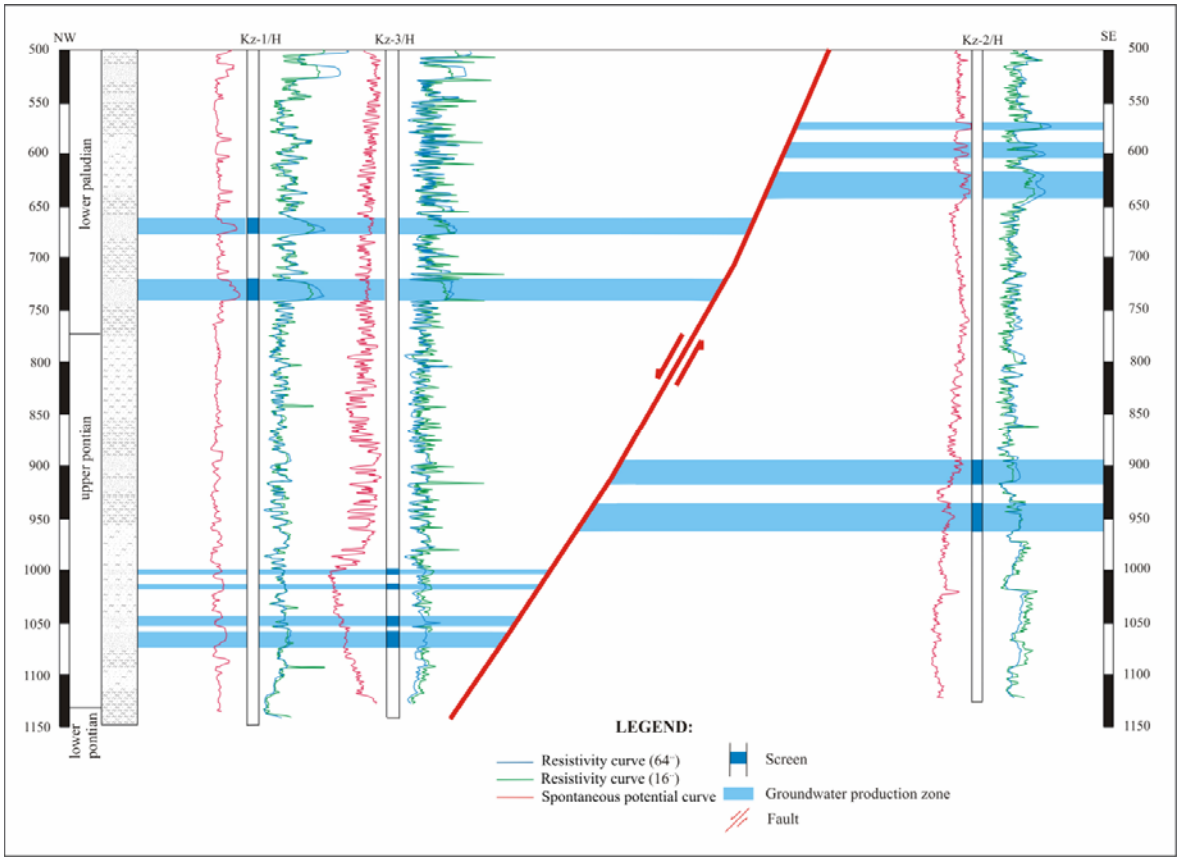

Figure 3. Schematized hydrogeological cross section

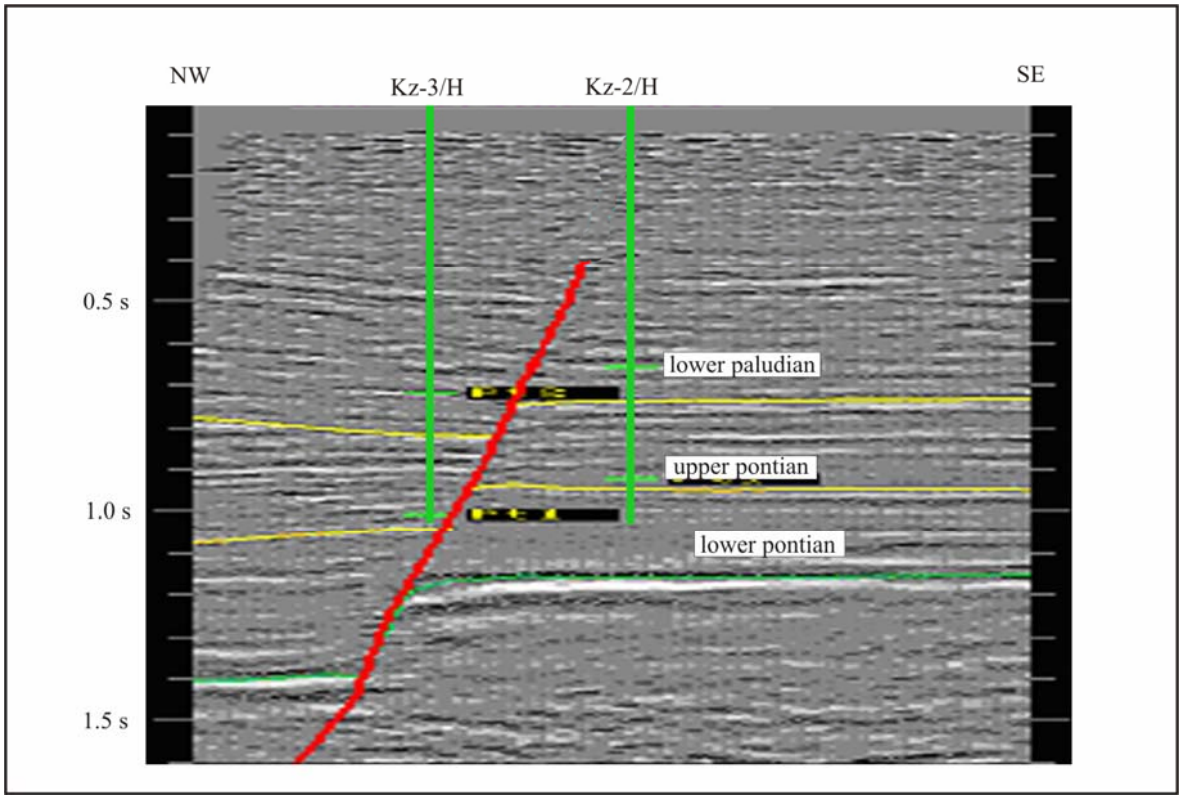

Figure 4. Time-section Mz1498 with well traces

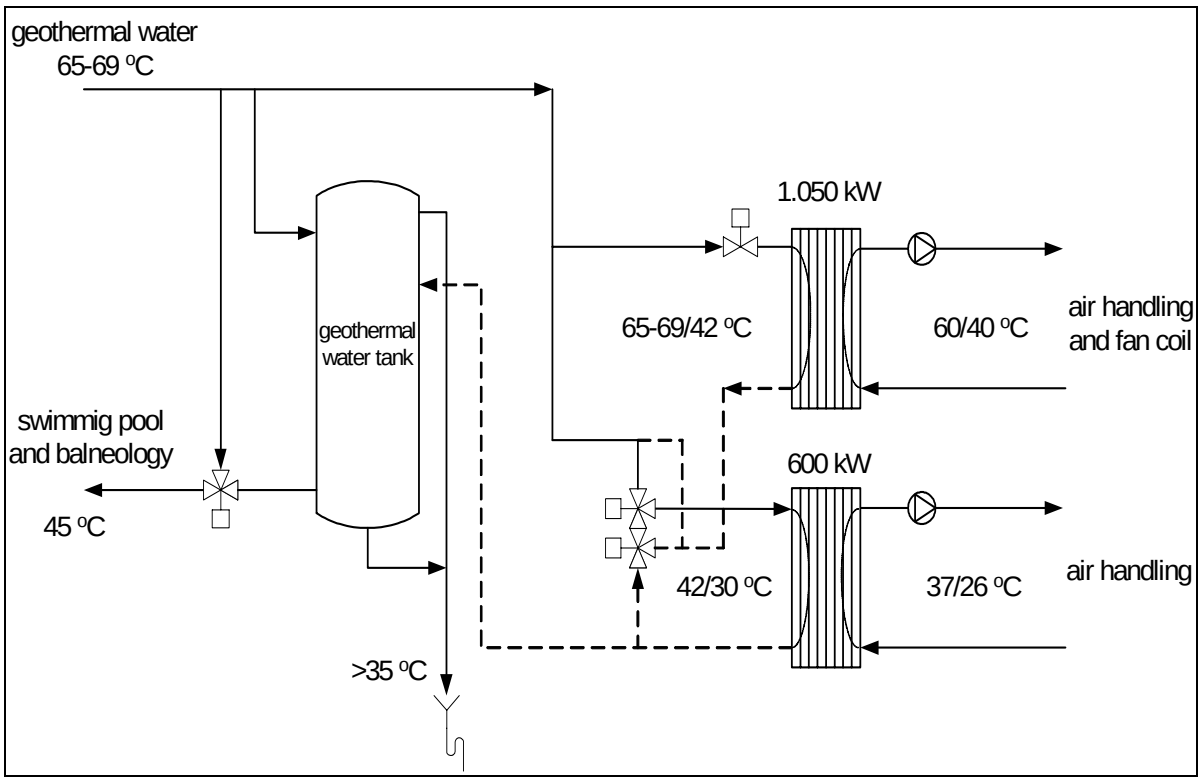

Fig 6: The present state of geothermal water utilization at the Kanjiza Spa