ECONOMIC THEMES (2018) 56(1): 91-104

http://www.economic-themes.com/

CONDITIONS AND POSSIBILITIES OF GEOTHERMAL ENERGY UTILIZATION TO ENHANCE ECONOMIC-TOURISTIC DEVELOPMENT OF JOŠANIČKA BANJA

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UDC 338.486:551.23(497.11)

Review paper

Abstract: According to the temperature, thermomineral water can be used for various balneological treatmens, as well as for agriculture, communal economy, electro economy, etc.This paper analyses homeohtermal (36°C) and hiperthermal (78°C) waters of the spa Jošanička banja which, together with that of Sijarinska (70°C) and Vranjska banja (90-110°C) are some of the hottest waters in the Republic of Serbia. Besides the temperature for balneo and wellness therapies, also very important are mineral properties which show that the water of the spa in question is characterised by the law level of mineralisation with slightly increased concentration of fluorine, sulfate, metabolic acid, silicon dioxide and similar compounds, which makes them suitable for the treatment of degenerative and inflammatory rheumatism, muscle disease, lumbago, sciatica etc. Based on the analysis of the water temperature and yield of dozens of springs with hiperthermal water, thermal capacity of spa water is determined as well as the possibility of using it in the electro economy, communal economy and agriculture. In conclusion, the use of thermomineral water during balneological treatmens can have different, more practical and more economic model. Practice shows that partial use of healing thermomineral water represents a significant loss in energy on the one hand, where, on the other hand, direct discharge of hot water can negatively affect individual components of the enviroment.

Received: 05.03.2018
Accepted: 02.04.2018

Keywords: Jošanička banja, thermomineral water, tourist valorization, balneological treatments, heat capacity

JEL classification: M37, O12, O13.

1. Introduction

Hot springs - spas have been used even in the ancient period for swimming and rehabilitation. Going to places with healing springs as the forerunner of the modern spa tourism was widespread in the Roman Empire. The ancient Romans built near hot springs baths, swimming pools, water supply systems, floor heating systems, drainage, sacred objects, and not far from these, summer houses, amphitheaters, urban settlements, military fortifications, roads, etc. These facilities were basically used to maintain health and war readiness of troops on the way of new conquests and maintenance of the already conquered territories. Even then the basics of the health treatment tourism were introduced. Traces of material culture from the Roman period were found in many of the Apennines spas, in Central Europe and Serbia (Niška banja, Vrnjačka banja, Gamzigradska banja), etc. (Stanković, 2008).

Thermo-mineral (TM) waters utilization in Serbia has a much longer history than their scientific research. The material remains and preserved cultural heritage of the Middle Ages (monasteries, old cities) are located near the TM springs. During the Ottoman rule from the 15th to the 19th century, baths were built, known as hamams around the mineral springs in Serbia (Protić, 1995).

Scientific publications referred to in the first decade of the 21st century dealt with TM springs in Serbia from the aspect of their use as a renewable energy source, the possibilities of substitution of fossil fuel, radioactivity of water, exploitation in spa tourism and the conditions and possibilities of the thermo-mineral waters utilization for the spa purposes (Milivojevic & Matinovic, 2005; Joksimović & Pavlović, 2013).

Tourist major Serbian spas have developed around thermo-mineral springs in the basin of the Western Morava and Southern Morava rivers. The regional-geographic approach to tha spa research corresponds to 10 spas division zone,according to which Jošanička banja belongs to the Kopaonik zone. These are typical European spas located next to the very springs of the thermal mineral waters in the suburban zones. In spas there were constructed rehabilitation centers, i.e. specialised hospitals with the ancillary objects that directly used the TM waters. However, tourisism oriented function of the spas is secondary due to a rooted traditional treatment concept of spas in Serbia (Jovičić, 2008; Marković, 1980).

Exploration of the geothermal energy in Jošanička banja in the past was linked to the possibility of its use for the therapeutic purposes and for settlements heating. Thermo-mineral springs in Jošanička banja did not attract the attention of researchers because of their peripheral position in relation to the main sources of geothermal energy in Serbia (Luković, 1970).

The aim of this paper is to examine the possibility of using thermal mineral waters in Jošanička banja for economic, biological and tourism purposes. In this regard, the paper analyses the effect of the geological conditions on occurrence of

the thermal mineral waters of Jošanička banja, given the classification and systematisation of their origin on the basis of the physical, chemical and therapeutic qualities, and provides an overview of the existing and potential utilization of thermal mineral waters for business, therapeutic and tourist development of Jošanička banja.

2. Regional survey and geological conditions of Jošanička banja

On the territory of Serbia, old tectonic masses of the Rhodope and Pannonian land and younger fold orogenic zone of the Dinarides and the Carpatho-Balkan mountains touch, converge and clash. On these contacts, in faults zones, there are thermal and mineral springs, where the tectonic lines (longitudinal and transversal) have cut earth's crust to the greater depth and have reached magmatic ore deposits. Therefore, a large number of thermal and mineral springs related to the fissure lines of the Rodope masses where Jošanička banja is located (Rodić & Pavlović, 1994).

According to the geothermal potential Serbia is one of the richer countries. The current results show that the intensive research and development program in Serbia until 2017 could achieve replacement level of 500 000 tonnes ofthe imported liquid fuels per year.

The density of geothermal heat flow (mW/m^2) is the main parameter for assessing the geothermal potential of any given area. The density of geothermal heat flow is the amount of geothermal heat, which in a unit of time, through the unit area, comes from the Earth's interior to its surface. However, the density of geothermal heat flow towards the surface of the Earth is not the same everywhere. It is different and depends on the composition - the material of the Earth's crust and their thermal conductivity coefficient (conductivity). The average value of the density of geothermal heat flow for the continental Europe is about 60 mW/m^2, and for the largest part of the territory of Serbia it ranges from 80 – 110 mW/m^2. In the Panonnian basin, the central part of the southern Serbia and in the central Serbia the density of geothermal heat flow is more than 100 mW/m^2 (Pavlović et al, 2013).

Jošanička banja is located at 42°33’11’’ north latitude and 21°59’19’’ east longitude, at 550 meters above the sea level, 20 kilometers east of the moutain of Kopaonik. According to the political-administrative division, Jošanička banja is located within the Raška District with its seat in the town ofRaska.Jošaničkabanja has the Jošanica river flowing through. According to the official census of the population, households and apartments in 2011, Jošanička banja has 5 347 inhabitants, out of which 70% are Serbs and 27.6% are the Roma minority (Marković & Pavlović, 1995).

Jošanička banja has multiple springs of geothermal water. Almost all springs are grouped in a zone which extends in the southwest-northeast direction, in the total length of 60 kilometers, and follows the valley of the river Jošanica. They are

conditioned by faults and volcanic rocks that occur there. The appearance of the thermal springs is localized to the circumference of an extended river Jošanica valley, volcanic rocks contact and crystalline proterozoic shale (Protić, 1995).

3. Research methods and data

Springs of Jošanička banja whose temperature ranges from 36°C to 78°C are among the warmest in Europe. So far 10 springs were capped, 4 of which are bigger ones with a discharge of 6-44 l/s, with different temperatures and chemical composition of the water. Based on the previous studies the discharge of the Jošaničkabanja springs A-1, A-2, EX-2 and 3 VG goes up to 60 l/s.

In this paper, for the examination of the chemical composition of the geothermal water springs in Jošanička banja ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry) device was used. Water springs discharge(l/s), the depth (m) and temperature(°C) were taken from the literature Stojiljković et al. (2015).

The heat capacity of the water springs in Jošaničkabanjawas calculated using the following formula:

$$C= m\ Cp\ \Delta T \quad (1)$$

where m is - mass flow rate of water (kg/s),

Cp = 0,004186 KJ/kgK specific heat of water,

T_2 – water inlet temperature (K),

T_1 – water outlet temperature (K),

In this way obtained heat capacity is expressed in units kW.

The energy that is generated in a certain time interval is calculated using the formula

$$E= C\ t \quad (2)$$

where

C - isheat capacity ofwater (kW)

t – is time in seconds (s) for which the energy which is obtained by means of the respective water springis calculated.

In this way, the resulting energy is expressed in units J.

Based on the data of the geothermal springs water temperature in Jošanička banja shown in Table 1 and their discharges expressed in l/s, the paper gives two hypothetical cases of Jošanička banja geothermal water utilization. The first case considers a possibility of the utilization of water temperature of up to 37°C, while

the second case discusses a possibility of the utilization of water temperature of up to 25°C.

Example:

I case – utilization of water temperature of up to 37°C ΔT_1= 78°C - 37°C = 41°C

II case – utilization of water temperature of up to 25°C ΔT_2= 78°C -25°C = 53°C

Usual temperature used in the TM waters calculations is given as a second case (use of up to 25°C).

3.1. Thermomineral water springs of Jošanička banja

The first data on the geothermal water temperature in Jošanička banja were recorded in 1893 by the famous geologist Jovan Žujović. In 1974 Vujanović and Teofilović gave detailed information on the physical - chemical characteristics and the radioactivity of some water wells in Jošanička banja (Marić, 2015).

3.2. Temperature and the discharge of geothermal springs in Jošanička banja

Over time, several shallow and deep hydrogeological wells have been formed in Jošanička banja. In 1980, on the seventh meter of one water rig water temperature measured was 99ºC. Deep well rigs (2 020 meters) encompass a well rig placed near the railway station in 1981. The total discharge of the spring and the water rigs of the geothermal wells in Jošanička banja were assessed to 80 l/s. Then, at a depth of 1500-1575 meters a measured rock temperature was 124ºC. Research has shown that in Jošaničkabanja at a depth of 1-1.4 meters there are temperature anomalies in the inner springs area temperature of 40-50ºC. This anomaly is recorded in a length of 500 meters and a width of about 100 meters, and extends in the south-north-west direction, which corresponds to the provision of a fault along the Josanica river (Vujović & Teofilović, 1983).

Based on the report of experts from France in 1970, Canada and New Zealand in 1981 and 1984, it can be concluded that there are possibilities of obtaining water temperature of 130-150ºC in the deeper parts of the terrain at the site in Jošanička banja.

Recent investigations have shown that all springs of geothermal water in Jošanička banja occur in the form of springs of the developed type, capped by one collecting channel - a heat pipe. The most important springs so far studied and capped, are shown in Table 1. Thermal water from these springs is of an artesian type, that is, rises to the surface of the earth on the basis of an internal overpressure so that it does not consume additional energy for its production (Stojiljković et al, 2015).

Table 1. Some characteristics of springs in Jošanička banja

	Name of spring	Discharge of spring (l/s)	Depth (m)	Temperature °C	Capacity (MW) I case	Capacity (MW) II case	Energy use (TJ/yr) I case	Energy use (TJ/yr) II case
1.	Gornji izvor	1.2	-	78	0.21	0.27	6.49	8.40
2.	Spring B1	2.0	26	92	0.46	0.56	14.52	17.69
3.	Spring A1	0.5	2	91	0.11	0.14	3.56	4.36
4.	VG-2	27.0	163	111	8.36	9.72	263.76	306.53
5.	Spring A3	2.1	20	91	0.47	0.58	14.97	18.30
6.	Spring B2	1.0	7	96	0.25	0.30	7.79	9.37
7.	Spring B3	1.5	12	87	0.31	0.39	9.90	12.28
8.	Collecting channel	50-70	-	84	13.77	17.29	434.31	545.20
9.	Spring A2	1.0	25	84	0.20	0.25	6.20	7.79
10.	VG-3	21.5	160	120	7.47	8.55	235.57	269.63
Total		**127.8**						

According to water temperature on the surface from 78°C at Gornji izvor and water temperature of 84°C at A2 spring, waters of Jošaničkabanja belong to hyperthermiac waters. The average discharge of these two springs is 1.1 l/s. However, at greater depths, the temperature reaches 111°C (VG-2 spring at depth of 163 meters) and even 120°C (Vg-3 spring at depth of 160 meters). Its average discharge is 24.3 l/s.

4. Physical - chemical characteristics of Jošanička banja water

Table 2 shows physical - chemical characteristics ofJošaničkabanja waters measured on springs VG-1, VG-2, VG-3 and A-1 respectively, obtained by ICP-OES device.

According to the mineral composition waters are of hydro-carbonate-sodium type (HCO_3 Na) and almost neutral at the VG-2 source whose pH value is 7.3. In other observed springs water is slightly basic and the pH ranges from 7.7 to 8.1. As dominant elementsone allocates sodium (900 mg/dm^3), calcium (30 mg/dm^3), magnesium (17 mg/dm^3) and potassium (350 mg/dm^3). According to these data, the mineral composition of the geothermal water spring VG-2 gives a possibility for versatile applications in balneotherapy. By chemical composition bicarbonates HCO_3 stands out as the macrocomponent in the amount of 430 mg/dm^3.

The water contains also a high concentration of fluorine (8-8.5 mg/l). At the beginning of the 20th century, many scientists linked fluorine with several disorders of the central nervous system, respiratory diseases, as well as arthritis and musculoskeletal disorders (Varga, 2010).

Table 2. Physical - chemical characteristics of springs VG-1, VG-2, VG-3 and A- 1

	Characteristics/ spring	VG-1	VG-2	VG-3	A-1
Ingredient mg/dm^3	Sodium (Na)	320	880	900	290
	Calcium (Ca)	30	21	19	20
	Magnesium (Mg)	2,4	2.1	1.5	17.0
	Potassium (K)	9	230	350	12
	Iron (Fe)	0.30	0.12	0.09	0.40
	Barium (Ba)	55	-	-	50
	Strontium (Sr)	1.7	-	-	700
	Lithium (Li)	158	-	-	-
	Ammonia (NH_3)	0.60	0.04	0.04	0.30
	Chloride (Cl^-)	57	42	44	62
	Bicarbonate HCO_3	384	409	430	414
	Sulphate SO_4	365	360	62	368
	Dry resident	1 269	1 053	1 080	1 291
Size	pH	7.7	7.3	8.1	7.9
	Conduct. µS/cm	1 700	1 240	1 300	1 503
	Total hardness °DH	3.40	3.41	3.04	2.90
	Constant hardness °DH	0.60	0.61	0.67	0.60
	Fuzziness, NTU	1.6	1.3	1.3	1.5

Apart from these, medical benefits of Jošanička banja's waters are derived from potassium, lithium, rubidium, cesium, strontium, barium, cobalt and sulfur. In the waters of Jošanička banja there is no sulfur-hydrogen. In the dry residents ofJošaničkabanjawaters one finds mostly iron, aluminum, strontium, lithium, manganese and rubidium, and a gas part is dominated by 70% nitrogen.

5. Possible utilization of thermomineral water springs of Jošanička banja

5.1. Balneology

Due to the high temperature waters of Jošanička banja are used for spa purposes, after some cooling for bathing and inhalation. Thermomineral waters of Jošanička banja are important for the treatment of the locomotor apparatus, degenartive rheumatism, discopathy, sciatica, lumbago, muscle atrophy, extraarticulary rheumatism, states after bone fractures, surgery to bone and joint pain, neurological disorders, gynecological disorders and diseases of the digestive tract, the intestines, stomach, liver, kidney, diabetes, lymphoid and anemic states, etc.

In the *Institute for prevention, treatment and rehabilitation*in Jošanička banja, which has its own accommodation capacities, modern methods of treating patients with degenerative rheumatism and post-traumatic conditions are carried out with the use of mud packs.

5.2. Tourism

Due to the high temperature, waters of Jošanička banja are used for spa purposes, after some cooling for bathing and inhalation. Thermomineral waters of Jošanička banja are important for the treatment of the locomotor apparatus, degenartive rheumatism, discopathy, sciatica, lumbago, muscle atrophy, extraarticulary rheumatism, states after bone fractures, surgery to bone and joint pain, neurological disorders, gynecological disorders and diseases of the digestive tract, the intestines, stomach, liver, kidney, diabetes, lymphoid and anemic states, etc.

In the *Institute for prevention, treatment and rehabilitation* in Jošanička banja, which has its own accommodation capacities, modern methods of treating patients with degenerative rheumatism and post-traumatic conditions are carried out with the use of mud packs.

For the purpose of the spa treatment and tourism now there are more facilities in Jošanička banja which include hotel *Izvor* built in 1931, rebuilt in 1946 and 1997, *villa Balkan* and private households. In the period between the two World Wars Jošaničkabanja had the highest number of overnight stays than all the spas in Serbia. From 1924 to 1940 the number of visitors has increased by four times, and the number of overnight staysby twelve times. The average length of stay of visitors depended on the decision of the doctor.

Shortly before the Second World War in 1939, when Jošanička banja was excelling on its reputation for healing and richness of content, it was visited by 4 800 tourists who made 76,926 overnight stays. By the number of tourists it was then ranked fourth in Serbia, and by the overnight stays second. In 1971, there were 16 000 registered tourists making 77,727 overnight stays. Over the next few years the number of tourists and overnight stays increased slightly and Jošaničkabanja ranked tenthamong the most visited spas in Serbia. In 1978 there were 27 376 tourists, a year later 96,436 overnight stays were realised.

After the Second World War a larger number of visitors was registered. In the period from 1959 to 1966 there have been increased visits to Jošanička banja, due to organised tourist attractions and cultural events. It also attracted a large number of visitors from Italy, West and East Germany, Switzerland, Greece, Poland, France, Great Britain, Austria and Japan.

From 1988 to 1996 in Jošanička banja not a single room was built, which was reflected in tourism development. Spa tourism is neglected, new hotels are not built, and for that reason the number of visitors decreased. Since 2000, tourist traffic recorded a gradual growth. The highest number of arrivals and overnight stays are realised in the summer months - July, August and September, when it is the most pleasant time to visit Jošanička banja. Beside these months, higher turnover is also recorded in April (Čomić, 2008).

Table 3. Tourist turnover in Jošanička banja in 2015 and 2016

Year	Arrivals			Overnight stays			Average Overnight stays	
	Domestic	Foreign	Total	Domestic	Foreign	Total	Domestic	Foreign
2015.	3 762	200	3 962	22 761	905	23 666	6.1	4.5
2016.	5 489	614	6 103	34 975	2 234	37 209	9.4	7.1

Source: Statistical Office of the Republic of Serbia Municipalities in Serbia, Population Census (2010)

Regarding the number of arrivals and overnight stays, of both domestic and foreign tourists between 2010 and 2012 there was a slightly downward trend, but that number increased drastically in 2013. Tourism in Jošanička banja as compared to 2013, doubled during 2015 and 2016 (Table 3). This happened due to the improvement of transport infrastructure, tourism services, infrastructure arrangement of Jošanička banja, as well as an increase in accommodation facilities.

The formation of the *Natural History Museum* with various types of insects, plants and animals would contribute to a significant extent to the promotion and development of Jošanička banja.

5.3. Economy

The use of utilised and unutilised TM waters within the spa cycles may have a different, more convenient and more economical model. The practice of spas in Serbia has shown that partial use of thermal water energy represents a loss of energy, and direct discharge of thermal water in nature can create environmental problems (Dokmanović et al, 2012).

5.4. Utilization of water with a temperature of up to 37°C

If, on the basis of the data shown in Table 1 one implies the utilization of geothermal water in Jošanička banja with temperatures of up to 37°C, the conditions are created for the heating of the greenhouse complex surface of 32 ha, and flowercultivating during the winter months when the ambient temperature is-18°C. For example, great importance would have the cultivation of carnations, spanning over 300 species, which are not resistant to low temperatures. It would certainly be of great use both for domestic and foreign markets.

5.5. Utilization of water with a temperature of up to 25°C

In this case, an opportunity would be created for sports and recreation complex and the Olympic swimming pool heating that would enable swiming in the winter months without additional electricity heating. Aslo, one could cultivate fish such as carp, grass carp, crucian carp, pike, chub, or other fish that are not characteristic for our region and live in water with a temperature of 20-30°C. It is possible to cultivate exotic aquarium fish like the Oscars, ancitrus, Blue Akara, etc. Specific use of geothermal energy for agricultural purposes and industrial processes, in addition to its use in greenhouses and for space heating purposes, includes chemical processes, heating kilns of fruits and vegetables, drying of tobacco, cultivation of medicinal plants, paper production, distillation, etc.

Potential of Jošanička banja's waters is partly seen for therapeutic purposes. Health infirmary Jošanička banja provides hydrotherapy, massages, drinking water, underwater massage and pearl baths. Thermal energy is utilised to heat the dispensaries accommodation capacity, hospitals and the Izvor hotel. In most cases, space heating is accomplished by means of heat exchangers. Heat exchanger stations are located in manholes along the route of direct heat source. If we also take into account the collection channel, which draws a quantity of water of 50-70 l/s with an average temperature of 84°C at a distance of 2 km, it can be concluded that it reaches the user, with a temperature of 40°C. From the consumer,unused water goes to the Josanica river with a temperature of 35°C (Varga, 2010; Kostić et al, 2014).

Taking into account that energy sources are limited, and that the environment is compromised and polluted, it is necessary to observe more complete utilization of geothermal energy for the business tourism development of Jošanička banja and the Republic of Serbia as well.

6. Conclusions

By its geothermal potential Serbia is one of the richer countries. Research over past 50 years have indicated the existence of significant quantities of thermal mineral waters that appear in different tectonic zones and on faults of the Rodopida which accommodates the Jošanička banja.

Jošanička banja has a number of sources of geothermal water whose temperature is between 36°C and 78°C and a total discharge of 127.8 l/s. Almost all sources are grouped in a zone which extends in the southwest-northeast direction, in the total length of 60 kilometers, and follows the valley of the river Josanica. Recent investigations have shown that all sources of geothermal water in Jošaničkabanja occur in the form of springs that are of the developed type, capped by one collecting channel - heatpipe.

Based on the results obtained in this study, following can be concluded:

- that in the waters of Jošanička banja, as the main element occurs sodium (900 mg/dm^3), calcium (30 mg/dm^3), magnesium(17 mg/dm^3) and potassium (350 mg/dm^3), which provides the opportunity for multiple uses in the rehabilitation and balneotherapy.
- that according to the temperature of water on the surface of 78°C at Gornji izvor and a water temperature of 84°C at A2 source, Jošaničkabanjawaters belong to hyperthermiac waters. The average discharge of these two sources is 1.0 l/s. However, at greater depths, the temperature reaches 111°C (VG-2 Source at a depth of 163 meters), and record 120°C (Source Vg-3 at a depth of 160 meters). Its average discharge is 24.3 l/s.
- that by mineral composition waters are of hydrocarbon-sodium type (HCO_3 Na) and almost neutral at the source VG-2 whose pH value is 7.3. In other observed sources water is slighly basic and the pH ranges from 7.7 to 8.1. By the chemical composition bicarbonates HCO_3 stand out as macro component(430 mg/dm^3).
- In order to highlight the possibilities for economic development by using geothermal energy of Jošaničkabanja, the paper concludes that:
- with geothermal water in Jošanička banja with temperatures of up to 37°C, the conditions are created for the heating of the greenhouse complex surface of 32 ha, and flower cultivating during the winter months when the ambient temperature is - 18°C. For example, great importance would have the cultivation of carnations which are not resistant to low temperatures. It would certainly be of great use both for domestic and foreign markets. The formation and heating of the *Natural History Museum* with various types of insects, plants and animals would make it accessible to the public all year round.
- water with a temperature of 25°C can heat sports and recreation complex and the Olympic swimming pool in the winter months without additional electricity heating. Aslo, one could cultivate fish such as carp, grass carp, crucian carp, pike, chub, or other fish that are not characteristic for our region and live in water with a temperature of 20-30°C. It is possible to cultivate exotic aquarium fish like the Oscars, ancitrus, Blue Akara, etc. Also, it is possible to use hot water for agricultural purposes and industrial processes, for heating kilns of fruits and vegetables, drying of tobacco, cultivation of medicinal plants, paper production, distillation, etc.

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USLOVI I MOGUĆNOST ISKORIŠĆAVANJA GEOTERMALNE ENERGIJE U FUNKCIJI PRIVREDNO-TURISTIČKOG RAZVOJA JOŠANIČKE BANJE

Apstrakt: *U zavisnosti od temperature termomineralne vode, mogu biti korišćene za različite balneološke tretmane, ali i u poljoprivredi, komunalnoj privredi, elektroprivredi i dr. U ovom radu analiziraju se homeotermalne (36°C) i hipertermalne (78° C) vode Jošaničke banje koje, zajedno sa vodama Sijarinske (70°C) i Vranjske banje (90 - 110°C), spadaju u najtoplije u Republici Srbiji. Pored temperature za balneo i welness terapije bitna su i mineraloška svojstva koja ukazuju da vode proučavane banje karakteriše nizak stepen mineralizacije sa nešto povećanom koncentracijama fluora, sulfata, metaborne kiseline, silicijum dioksida i sl. što ih čini pogodnim za lečenje degenerativnog i zapaljenskog reumatizma, oboljenja mišića, lumbaga, išijasa i dr. Na osnovu analize temperature i izdašnosti desetak izvora sa hipertermalnim vodama utvrđen je toplotni kapacitet voda banje i mogućnost njihovog korišćenja u elektroprivredi, komunalnoj privredi i poljoprivredi. U zakjučku rada se konstatuje da korišćenje termomineralnih voda tokom balneoloških tretmana može imati drugačiji, praktičniji i ekonomičniji model. Naime, praksa pokazuje da da delimična upotreba lekovitih termomineralnih voda predstavlja s jedne strane značajan gubitak u energiji, a s druge strane direktno ispuštanje toplih voda može negativno uticati na pojedine komponente okružujuće sredine.*

Ključne reči: *Jošanička banja, termomineralne vode, turistička valorizacija, balneološki tretmani, toplotni kapacitet.*

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