Review article UDC 553.78(497.11)

Received: 26. October 2017; doi: 10.5937/zrgfub1765251G
Received in revised form: 8. November 2017;
Accepted: 24. November 2017;
Available online: 7. December 2017

EXISTING STATE OF EXPLORATION OF HYDROGEOTHERMAL POTENTIALS AND THE POSSIBILITY OF THEIR USE IN THE TERRITORY OF BOGATIĆ MUNICIPALITY

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Abstract: Geothermal, that is, hydrogeothermal energy is an important resource that can contribute to the energy independence of the state. In the conditions of the modern energy crisis, renewable natural resources based on hydrogeothermal potential are invaluable. The municipality of Bogatić, as part of Mačva, is one of the most promising hydrogeothermal sites in Europe. The main reservoir of low mineralization geothermal waters consists of karstic Triassic limestone and dolomite. In the main reservoir, it is realistic to expect water temperatures up to 100°C which can be used for heating purposes, in agriculture and aquaculture, industry, for balneotherapy, sports, recreation, and electricity production. Socio-economic, technical and technological and ecological advantages are numerous in comparison to other sources of energy. Considering that this is a region that has significant land potential, the production of food, primarily vegetable in greenhouses, based on the use of thermal energy, should be a priority for the whole region and the municipality of Bogatić.

Key words: hydrogeothermal potential, cascading use, municipality of Bogatić.

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Introduction

In conditions of increasing energy instability, European countries are striving to reduce energy dependence while attempting to increase energy production. There are chances to increase the share of renewable sources in the overall energy balance. Serbia is in a similar energy dependence on imports and therefore it is very important to approach the increase in the use of geothermal energy. In the next 10-20 years, it is possible to provide over 10% of the heat demand with the lowest investment in comparison with other sources. When it comes to hydrogeothermal energy, it has multiple significance and application in the world. Its exploitation is so perfect that almost every source or well can be energy-efficient regardless of the quality of water and the content of dissolved minerals and gases in it, while respecting ecological requirements. Unlike world conditions, the level of research and use of the energy of geothermal waters has not yet found its right place in our country, although Serbia is extremely rich in hydrogeothermal resources.

Numerous studies, works by scientists and experts around the globe, organized meetings, including world hydrogeothermal congresses, indicate the actuality of the problem related to hydrogeothermal energy and its use. The last World Geothermal Congress was held in Australia, in Melbourne in 2015. A contribution to the study of hydrogeothermal energy, degree of research and its application is evident in Germany (Weber, J. et al., 2015); Italy (Razzano, F. and Cei, M., 2015); Poland (Sowizdzal, S., 2017), in Iceland (Ragnarsson, Á., 2015); India (Richter, A., 2016); Philippines (Fonda, A. D., Marasigan, M. C. and Lazaro, V. S., 2015); Japan (Yasukawa, K. and Sasada, M., 2015); Turkey (Melikoglu, M., 2017); Mexico (Gutiérrez-Negrín, L. C. A. et al., 2015) and other countries. The economic advantages, natural conditions and political conditions in the world have imposed the need to pay increasing attention to the issues of renewable energy, with applicability coming to full expression. Lund & Boyd (2016) point out the possibilities and importance of direct use of geothermal energy in 2015 worldwide. Terrapon-Pfaff, Dienst, Konig, Willington & Ortiz (2014) emphasize the impact and sustainability of small renewable energy projects in developing countries. Limberger, Boxemb, Pluymaekersb, Bruhncd, Manzellae, Calcagnof, Beekmana, Cloetingha, and Jan-Diederik van Weesab (2018) provide a global assessment of the resource base for the direct use of geothermal energy in deep aquifers. Richter (2016) points to the success of a geothermal project in providing heat to the Himalayas, while Alpera & Oguzb (2016) highlight the economic importance of using renewable energy sources and the role of its consumption in economic growth through evidence of asymmetric causality.

In Serbia, Svetolik Radovanovic is considered the founder of geothermology and geothermal explorations, and a great part of his work "Подземне воде" from 1897 was directed to geothermal energy. His work "On the Geothermal Degree of Tertiary Terrain near Mladenovac", published in the same year, was the first scientific work in Serbian language in geothermal science. An important period for research work relates to the period after 1975, when the term geothermal energy appeared and the Laboratory for Geothermal Energy was founded. Perić and Milivojević in 1981 published the results of a pilot study on the geothermal potential of the Avala-Kosmaj-Bukulja-Rudnik area, and ten years later they published the results of the study, that is, gave an Evaluation of the Energy Potential of Geothermal Resources of the territory of Serbia without Vojvodina, Kosovo and Metohija. Contribution to hydrogeothermal research in the territory of Serbia is given through papers and studies of domestic researchers (Перић, Ј. et al., 1982; Миливојевић, М. et al., 1982,1984,1996, 2012; Протић, Д. et al., 1998; Martinović, M. et al., 2000; Milenić, D. et al., 2010, 2016; Gajić, M. et al., 2005, 2009; Dokmanović, P. et al., 2012; Joksimović, M. et al., 2014; Vranješ, A. et al., 2015; Krunić, O. et al., 2017).

Serbia has significant hydrogeothermal resources, which is primarily reflected in the occurrence of over 150 natural sources of thermal waters with temperatures exceeding 15°C. The total flow rate of all natural sources is about 4,000 l/s. Thermal springs from karst limestone of Mesozoic age have the highest flow, followed by thermal springs in granitoid and volcanic rocks of tertiary age. The largest number of thermal springs is found in the Dinarides, then in the Carpatho-Balkanide, and in the Serbian-Macedonian massif. The smallest number is in the Pannonian basin and in the area of the Mezia Platform (Dacian Basin), only one respectively. Within the geothermal systems in the territory of Serbia, the estimated potential of the geothermal energy is about $400x10^6$ tons of equivalent oil, while the total estimated thermal power of groundwater, the use of which requires heat pumps is about 2,300 MW (Миливојевић, 2012).

Taking into account the degree of research and scope of use, the most important geothermal energy site in Serbia is currently located in the Vranjska banja spa where it is used in balneotherapy and for the heating of the greenhouse complex. The maximum registered thermal water temperature in the VG-2 well is 112°C. The total flow rate, based on the Elaborate on reserves, is 80 l/s. However, based on previous preliminary hydrogeothermal research, the most promising geothermal energy site is located in Mačva and represents an energy resource which, by using it, can significantly substitute imported oil, gas and coal. The total flow rate of the performed exploratory wells is 170 l/s of self-outflow with an average temperature of thermal waters of 70°C

(Миливојевић, 1990). Since it is one of the most promising hydrogeothermal regions of Europe, it opens wide possibilities for being of use both to the state and local administrative units which territories are located in this part of north-western Serbia. These are Šabac, Bogatić, Sremska Mitrovica and Loznica.

Spatial framework of research and work methodology

The municipality of Bogatić (384 km^2) occupies a central place in the territory of Mačva, includes 14 populated places, and is also a spatial framework for research in this paper. The aim of the research is to determine the existing state of hydrogeothermal resources exploration in the territory of the municipality and point out the possibilities of using it. Given that this is an area affirmed for agricultural production, together with fertile land and use of energy of geothermal waters, the municipality of Bogatić as well as the entire Mačva can become an even more important food producer not only for the needs of Serbia. Likewise, the goal is to point out the importance of the cascading use of geothermal energy, because only in this way a complete purpose effect would be achieved. Investing money for sports and recreational contents is not a bad investment, but the heating of facilities and food production must be the priority of the municipality. The paper presents the basic geological structure and the tectonic structure of the terrain, which caused the creation of existing hydrogeothermal reservoirs in the investigated area. Through the results of the paper, it is pointed to the distribution of the wells and the existing state of the field exploration, as well as the age, the chemical and physical properties of the geothermal water. Through the discussion, the possibilities of multipurpose use of these waters were pointed out, and the full effect and maximum use of this resource would be achieved.

General and specific methods of work were used in the paper. The most important are methods of analysis, synthesis, comparison and an evolutionary method. The method of analysis determines the structure of the explored area, where the significance of the phenomenon of geothermal water is determined. The use of this method resulted in results that reflect the current state of hydrogeothermal potentials, and by the method of synthesis, all factors that are important for the use and exploitation of these resources have been linked. Particular importance is given to the results of field research, which created the conditions for systematization and generalization of materials essential for undertaking activities that lead to the realization of adequate use of energy of geothermal waters, aiming at economic development of the municipality and the whole region.

Basic geological structure and tectonic features

In the geotectonic view, the territory of the municipality of Bogatić is located within two geotectonic units: 'Jadar Block' and 'Vardar zone' (Karamata, 1996). The space is characterized by complex tectonics, which is manifested by moving a large number of smaller blocks. In addition to deep cracks, which completely cut across the Earth's crust and represent the boundaries of geotectonic units, a large number of smaller faults were determined on the field by geophysical research (Gajić et al., 2005). Reconstruction of significant tectonic processes is possible based on characteristic lithographic and stratigraphic members and knowledge of global tectonic movements. The youngest tectonic movements are tertiary ages and last until today. Deep cracks and young magmatic and plutonic bodies are of great importance for the formation of thermal waters in this area. They are the cause of geothermal anomalies and the most significant deposits of thermal waters (Протић et al., 1998).

Low Earth's crust thickness (25-29 km) and high density of terrestrial heat flow (> 100 m W/m^2) are of significance for the geothermal potential of this area. The structure of the old land in the municipality's area, before it again became the seabed in the Neogene, was mostly made up of Triassic limestone and dolomite, and to a lesser extent upper Cretaceous marls and limestone sediments. Since the rocks of Jurassic age were not discovered, the karstification of Triassic limestone and dolomite was carried out throughout the whole Jurassic period, the Lower Cretaceous and the Palaeogene. Due to such paleogeographic conditions, which lasted about 70 million years, Triassic limestone and dolomite became porous and made excellent reservoirs primarily of cold and then thermal waters (Миливојевић et al., 1990). Within the boundaries of the Pannonian Basin, located between the present Dinarides, the Alps and the Carpathians, there were several smaller depressions. Mačva-Srem depression was one of them in which sedimentation began in the Miocene. The diverse geological composition of the rim enabled the inflow of various materials into the sea and the deposition of various rocks. This was also contributed by dissected relief of the former seabed.

The main elevation on the seabed was from Šabac to Bogatić. It represented a karst plateau of up to 20 km wide, built of Triassic and a minor part of Cretaceous limestone. South and north of that underwater ridge, located at an average depth of about 250 m, the depth of the seabed was considerably higher. Thickness of sediments in them is from 1,000-1,500 m. Their major part is deposited in the younger sections of the Neogene. This means that after the transgression of the Pannonian Sea (end of the Miocene, the beginning of the

Pliocene) in the present-day area of the municipality, in the bottom of Triassic limestone and dolomite, deposition of various shallow sediments (clay and marls with the layers of sand) begins. Owing to clay and marls which are the best hydro and thermal insulators, the withdrawal of the sea enabled warming of groundwater in Triassic limestone and dolomite beneath them. After the withdrawal of the Pannonian Sea at the end of the Miocene, there were numerous lakes and swamps in which a variety of shallow sedimentation was performed in the Pliocene and Quaternary. Below the thick alluvial deposits of gravel and sand (60-150 m) there is a series of colourful clay and clayey sand with layers of gravel of the Pliocene age. Coal clays and thin layers of coal occur in some levels. Sandy-gravelly material is important for the formation of thermal water deposits in the Neogene sediments (Gajić et al., 2009).

In Holocene, river erosion created the main lines of today's relief and an important hydrogeological complex. Namely, after the formation of the Drina valley, flooding of shallow lakes and swamps with fluvioglacial deposits began as a result of the rocks from the upper part of the basin. Thus, thick gravel deposits were created in which today there is a large phreatic outcrop with huge reserves of drinking water. With these sediments, the loessoid silt and clay are replaced, and in the end, real Quaternary loess is formed during the last ice age.

Research Results

Hydrogeothermal potential of Bogatić municipality

The discovery of geothermal water sites on the territory of the municipality is related to 1981, when a conductive anomaly was discovered in Dublje (6 km south of Bogatić). By exploration drilling at a depth of 178 m in Neogene sediments, a water temperature of 44°C was determined, and a self-outflow of 1.7 l/s was obtained from the well (Миливојевић et al., 1982). In order to examine the cause of the anomaly and the possibility of intensive exploitation of geothermal waters, in 1982, the exploration drilling DB-1 up to 400 m deep was carried out. The existence of accumulation in Middle Triassic limestone at a depth of 400 m was determined. From this well, a self-outflow of water with temperature of 50.5°C was obtained in the amount of 15 l/s (Миливојевић et al., 1984).

The most important hydrogeological phenomena were discovered by drilling in Bogatić. During 1986, the BB-1 well produced water temperatures of 75°C in the settlement itself, with a self-outflow value of 37 l/s. The best results were achieved in 1989, when the temperature of 78°C with a self-outflow of 60 l/s was obtained at 1.5 km north of Bogatić (Belišče site). The depth of this well was 618 m. This is considered to be one of the most abundant wells in Europe.

Figure 1 – *Thermomineral well in Bogatić*

In the Belotić settlement, 7 km from Bogatić, the exploration well BeB-1 is 450 m deep. The Neogene sediments are up to 350 m, and then Triassic dolomite limestone appear. A self-outflow of 25 l/s was obtained with a temperature of 35°C. In the Metković settlement, about a dozen kilometres away from Bogatić, the well BMe-1 is 630 m deep. The aquifer layer is located at a depth of 560 m to 630 m. The measured water temperature was 62.8°C. A self-outflow of 11 l/s of thermal water was obtained, but it did not come out of Neogene sediments (Миливојевић et al., 1990). The trial well is being prepared for exploitation.

By analyzing the results obtained by exploratory drilling in this territory, it is concluded that there is a lithological heterogeneity in the floor of Neogene sediments and at relatively small distances. From the hydrogeological point of view, the most important are the karstified Triassic limestone, which are the main reservoirs of geothermal waters. They were proved by the wells in Dublje (DB-1) and Bogatić (BB-1, BB-2).

Figure 2 - *Thermomineral well BB-2 in Bogatić (Beljište locality)*

Isotopic explorations have shown that waters from the BB-1 and BeB-1 wells do not contain the isotope tritium as opposed to the DB-1 well. These data indicate that water from the southern part of the reservoir is under 30 years old and that it originates from infiltration of precipitation and from river waters. The waters in the northern part of the collector are older than 50 years and they inflow from a greater distance, from Semberija and Srem. In the hydrogeothermal system of Mačva, it comes to mixing of cold and warm, i.e. younger and older waters from different areas of feeding. This also means that the flow of water through the reservoir is active. The flow of geothermal waters is fast, which is shown by small mineralization, but heating is high, since the inflow of cold water is constant (Миливојевић et al., 1996).

According to the chemical composition, the tested geothermal waters of all wells in the territory of the municipality belong to the hydrocarbon type Na-HCO_3 and the sodium group. The mineralization of water is small and varies from 807.0 to 1.082.5 mg/l. The dry residue ranges from 0.530 to 0.780 mg/l, the pH is from 6.8 to 7.2, so it can be characterized as neutral while nitrogen prevails in the gas composition. Since sodium ion content exceeds MDK, thermal waters can be used for drinking and other purposes after extraction of geothermal energy from them.

Discussion

Possibilities of using geothermal waters

Based on the quantity, physical and chemical characteristics of geothermal waters it can be concluded that the conditions for their use are favourable. Geothermal anomaly Dublje-Bogatić would gain full meaning by discovering hydrogeological collectors with a water temperature of 90°C to 100°C. The whole region is a part of the large hydrogeothermal system (south-eastern Srem, Posavina, Semberija and Mačva) of about 4,000 km^2 (Миливојевић et al., 1996). It is a unique accumulation of geothermal waters which is large and unused.

With the discovery of geothermal anomaly in Dublje, possibilities for future use of geothermal waters for balneological and sports-recreational purposes have been created. Due to high temperatures, alkaline waters of Dublje can be used for bathing, and cooled for drinking. Geothermal waters could be found in the treatment of chronic rheumatic diseases of the locomotor system and chronic skin diseases. Two pools with accompanying equipment were built in Dublje for this purpose, which would use thermal mineral water from the well DB-1 with a temperature of 50.5°C. This site should be affirmed as a future spa tourist centre.

On the basis of existing geothermal waters, the spa complex "Thermal Riviera" was built at the distance of four kilometres from the centre of Bogatić. The water temperature of 70°C is pumped from a depth of 771 m in an amount of 30 l/s. The complex contains three pools of different sizes that have over 2,360 m^2 of water surface; part of the open and part of the indoor swimming pool for adults with water hydro and aero massages, a children's pool with attractions and a jacuzzi with massagers. Next to the pool there are warm beds for rest. Accommodation capacities are modest so far, and accommodation is possible in apartment houses ("Azuro" and "Lorka" in Ruze Street). On the basis of the preliminary design, the complex will include two three-storey hotels, with a total area of 6,600 m^2 each, one of which will be for rehabilitation, the other with sport facilities, and an apartment complex with 130 one-storey houses[2]. In addition to the construction and equipping of a tourist and recreation complex for recreation that uses the geothermal potential of this region, the company "Thermal Riviera" will gain importance by organizing greenhouse production. The total area of the entire complex is about 20 ha.

[2] www.termalnarivijera.rs

Figure 3 - *Tourist-recreational complex Thermal Riviera*

In addition to spa tourism, thermal waters in the municipality provide opportunities for the production of environmentally valuable and profitable food. The use in agriculture results in economic effects because higher yields can be achieved by lower production costs. Hydrogeothermal energy, as the cheapest energy source, can be used extensively for plant production in greenhouses (vegetables, flowers, nursery plant, garden seedlings). Plastic covered greenhouses are especially suitable for cultivating agricultural crops that require more light (optimal temperature for cucumber cultivation is 25-30°C, tomatoes 20°C and lettuce 15°C). Anyway, greenhouse production in winter is unprofitable and expensive due to high consumption of fossil fuels. The use of hydrothermal energy would reduce production costs and enable work throughout the year. Hydrogeothermal energy is suitable for the breeding of livestock, poultry and freshwater organisms in the appropriate environment (fishponds). Different types of fish require a different water temperature, the regulation of which produces far higher production than the traditional one. Thus, for example, catfish grows up to commercial weight for 4 to 6 months at a temperature of 18-27°C, while trout requires temperature from 12°C to 18°C (Gajić et al., 2009). By regulating the temperature, faster development of organisms is achieved by 50 to 100%, which also increases the production.

Hydromineral agronomy Bogatic-Dublje could have a perspective of rapid and diversified ascent with additional research and investments. By building a greenhouse complex for the production of fresh vegetables and fruits in the winter period, their offer would be made throughout the year.

There is a great need for fresh vegetables during winter and quality nursery, which points to the need and economic justification of the use of domestic and ecologically pure hydrogeothermal energy. According to the previous world experiences, production would be realized in two production cycles (spring and autumn) with 5 ha of one greenhouse, except for lettuce that goes into the whole year's production cycle.

Culture	Average yield	Surface area (m^2)	Total yield
Cucumber	35 kg/m^2 (spring)	14,250	430 t
	20 kg/m^2 (autumn)	14,250	171 t
Tomato	30 kg/m^2 (spring)	24,000	480 t
	15 kg/m^2 (autumn)	24,000	290 t
Pepper	20 kg/m^2 (spring)	9,500	140 t
	10 kg/m^2 (autumn)	9,500	76 t
Lettuce	115 pieces /m^2	4,750	546,000 pieces

Source: Gajić et al., 2009

The qualitative and ecological effects of the use of geothermal waters refer to the enrichment of agricultural products with mineral substances, which is at the same time the prerequisite for achieving ecological goals, i.e. production of healthy food. In the production of food that has high energy requirements, watering of crops with thermal mineral water is becoming more and more present. Arable land is usually poor with essential micro-elements and other mineral substances that are not present in surface and shallow groundwater. In deeper thermal mineral waters, mineral substances are in dissolved and ionic form. Experience has shown that thermal mineral water has a favourable effect on the growth and development of plants.

Hydrogeothermal resources of the municipality can be used to heat the settlements. However, they are not yet used for heating the settlements, despite the fact that the whole region represents the most promising hydro-geothermal region of Serbia. With the exploitation of waters with the temperatures of 80-100°C it is possible to heat Bogatić and larger towns in the surroundings (Šabac, Loznica, Sremska Mitrovica).

A communal heating system requires large investments that represent a limiting factor of use. For heating purposes, a minimum water temperature of 70°C is required. By using heat pumps for heating, it is possible to use thermal water of lower temperatures as it is the case with Mačva. Experiences in other countries that have a long tradition of using these resources show that invested investments can be amortized for six to eight years, through savings in the cost of needed fuel. On the basis of existing resources, in this field it is possible to build a 500 MW geothermal plant, which would create the conditions of multifunctional, the so-called cascade use of heat of thermal waters (Martinović et al., 2000). Due to the wide use of geothermal water in industry (drying, evaporation, distillation, cooling, baking, washing and dyeing, processing of leather and fur, process heating and heating of industrial facilities), depending on the type of available geothermal water and the required temperature, agricultural products (vegetables, cereals, seeds), medicinal herbs, river and sea products, wood, etc. can be dried by heated air.

A significant step forward in the use of energy for heating is the Study of the possibility of using hydrogeothermal energy for the needs of remote heating of public facilities in Bogatić, at the beginning of 2017. The Study was done for the consideration of the possibility of installing a geothermal remote heating system in the area of Bogatić, in order to design an optimal and financially acceptable solution. The subject of the study was three elements of the system: resource, thermal technical installations with hot water network and users. The costs of the construction of the heating network will amount to 596,100 Euros, and the project will include the buildings of the pre-school 'Slava Kovic', the primary school 'Mika Mitrovic', the High schools in Mačva, the Municipalities, the Centre for Social Work, the Court, the Public Communal Company and the Police station. A technical-economic analysis has shown that this project can significantly reduce the costs of heating. The available quantities of water from the well BB-1 were checked and it was determined that it can obtain a quantity of water, which is limited to a temperature of 20°C, while the possibility remains that, after passing through all exchange systems, the flow of 25 l/s with 55°C is maintained for some other purposes[3].

It is necessary to make a preliminary solution and to provide location conditions, as there are no administrative and financial obstacles to the realization of this project. The municipality of Bogatić is one of the three, which in 2012, based on the feasibility study of the Ministry of Energy and Environmental Protection, entered choice for financing the heating of public institutions from the European Union funds. A year later, the rehabilitation of the BB1 well in Bogatić was done, and then the conditions for the PCC 'Bogatić' were made to perform measurements of the temperature and pressure on the well four times a year.

[3] www.bogatic.rs

The greatest economic effects are achieved by the cascading use of geothermal resources, which involves multiple use of the same geothermal fluid in order to achieve maximum benefit, efficiency and profitability. Based on the development of a simultaneous geothermal model, it is estimated that from the source in Bogatić it is possible to obtain 2,000 l/s of water with temperature 75-80°C. Thermal power of the geothermal heating plant Bogatić (500 MW) would first be used to heat rooms in the heating season with 250 MW. For the food production, industry and sports and recreational purposes, the capacities of other 250 MW would be used (Миливојевић et al., 1996).

Thermal waters with the highest temperature (up to 100°C) should be expected north of Bogatić. Water sterility is conditioned by their age, ranging from 15,000 to 26,000 years. The explored wells in the municipality have a total flow rate of 145 l/s, that is 4,575,000,000 l per year. On a daily basis, thermal waters produce energy that corresponds to the energy obtained by combustion of 63 t of liquid fuel, about 2,000 t of fuel per month, and annually about 24,000 t (Миливојевић et al., 1996).

Hydrogeothermal energy must be classified as primary energy sources, which has not been the case due to the lack of financial resources in the research, as well as the long lack of adequate legislation in matters of research priorities and use of this energy. Research, exploitation and use of hydrogeothermal energy must not be constrained especially if it is known that there are no significant fossil fuels and hydro-energetic potentials in this area. Existing partial use of energy of thermal waters is unprofitable, because only a small part of geothermal energy is put into the development function.

Conclusion

Geothermal, that is hydrogeothermal energy is a very important and unused resource that can contribute to energy independence and reduce trade deficit (replacement for imported fuels). Using geothermal energy reduces costs, as geothermal heating plants are cheaper than heating plants using fossil fuels. The costs of exploiting geothermal energy are the lowest in relation to other energy sources, since the outflow of water from the wells is most often self-outflow. It is ecologically most valuable resource, and without consequences for the health of people and animals. In exploitation and use, carbon dioxide (CO_2) is not generated, nor does it increase its amount in the atmosphere, as is the case with the use of fossil fuels, and its use does not increase the greenhouse effect. The municipality of Bogatić, as part of

Mačva, is one of the most promising hydrogeothermal sites in Europe. The main reservoir of low mineralization geothermal waters consists of karstic Triassic limestone and dolomite. It is realistic to expect water temperatures up to 100°C which can be used in a multipurpose manner. Socio-economic, technical-technological and ecological advantages are numerous in comparison to other sources of energy. The production of food, primarily vegetables in greenhouses, based on the use of thermal energy, should be a development priority. In the conditions of the modern energy crisis, renewable natural resources based on hydrogeothermal potential are invaluable. For this purpose it is necessary to conduct detailed hydrogeological research. Exploitation of geothermal waters in this area will represent the basic strategy of regional development. As there are no significant fossil fuels in the whole region, more attention has to be paid to the issue of using geothermal resources.

Hydrogeothermal energy can be used directly as heat and indirectly as mechanical or electrical energy. Thermal waters can be used for balneology, sports and recreation, for heating rooms, in agriculture and aquaculture, industry, technology and electricity production.

Acknowledgements

The paper is the result of the research within the project no. 176008 funded by the Ministry of Education and Science of the Republic of Serbia.

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