

# Mineral and Thermal Waters of Srem, Present and Prospective Usage

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## Abstract

According to the opinion of competent experts, a part of Srem south from the Fruška gora (along the Sava basin from Obrenovac to [abac and Mačva) represents one of the most prosperous regions for intensive exploitation and usage of geothermal waters. Consequently, the waters of Srem are part of a unique hydrothermal system of larger proportions. In this paper, we have analyzed basic characteristics of mineral and thermal waters of Srem. We have also determined the sites that have the largest resources and established the rate of their usage in terms of medical, balneological and recreational purposes. We have suggested how to make improvements in the most frequently visited centers, such as Vrdnik and Stari Slankamen. We have justified the statement that most other springs can be used only as individual segments of otherwise vast tourist offer of the Fruška gora or the entire Srem. Apart from usage of the waters for tourist reasons, we have explained the possibilities of using the discovered and potential waters for agriculture, aquaculture, heating, as technical water in agriculture etc.

Key words: Srem, thermal and mineral waters, medical and balneological tourism, and recreational tourism.

## Geological and Hydro-Geological Properties of the Terrain and Properties of Thermal and Mineral Waters

The investigation of oil, gas and geothermal energy across Vojvodina and in Srem (south-west parts of Vojvodina, between the rivers Danube to the north and east and Sava to the south), especially, near Adaševac and Voganj has shown that we can vertically (from top to bottom) separate three deep zones depending on historical and geological conditions: in the first zone there are quaternary, paludinske i gornjopontijske sediments, created in fresh water regime; in the second there are donjopontijski and Pannonian sediments, created in brackish water regime; and in the third there are Pre-Pannonian sediments, created in marine water regime. In accordance to the zonal genetic character of the layers, the quantitative changes of physical and chemical properties of underground waters are also prominent in the same direction (Aksin et al, 1976; Aksin et al, 1984).

Lythologically, the lower border of the first zone consists of non-porous sediments of lower PONT. The power of the zone is heterogeneous. It is the greatest in the northern Vojvodina, where the thickness of the sediments is up to 2000 m. The total mineralization of water is increased proportionally to the depth of the subsiding sediments and it ranges from 1g/l in the shallowest layers to 9,0g/l in the deepest ones. The first zone has got heterogeneous temperature of water in general, which can be divided into three series. The depth of the first series is 300-700m and its temperature varies from 25 to 40°C; the second series occurs on the depth from 700 to 1700 m and has got temperature from 40 to 60°C and the third series is on the depths of 1300 to 1500 m and has water temperatures ranging from 65 to 70 degrees Celsius.

Lythologically, the lower border of the second zone is a real mosaic of pre-Pannonian forms. Its greatest power is in the northeast parts where it reaches 1500 m, and decreases towards south where it reaches only 800 m in Srem. The total mineralization ranges from 4g/l to 20g/l with the presence of NaCl which varies from 1,5 to 12,0 g/l. Depending on the depth of the collectors the water temperature varies from 60 to 80°C, sometimes even up to 90°C and rarely up to 100 or 120°C.

The third zone consists of Tortonian and sarmatske sediments, pre-Tortonian and Tertiary sediments. Here we can find the strongest mineralization with 40 g/l. The percentage of salt NaCl is 80-90 % in total mineralization. The temperature of the water in the entire zone is over 100 degrees Celsius, and in the deepest parts regular temperature even goes up to 150°C (Protić, 1995).

According to the available data, twenty-seven negative gas and oil bores have been studied in Vojvodina so far, from the aspect of the usage of thermal and mineral waters. All of them are situated in Bačka and Banat. In Srem there are eight sites of thermal and mineral waters - Vrdnik, Stari Slankamen, Ljuba and Staro Hopovo Monastery (old sites), Kupinovo, Indija, Buđanovci and Sremska Mitrovica (new sites). Although Vrdnik, Stari Slankamen and Ljuba are natural thermal waters, the facilities used are manmade and natural springs have been abandoned. The thermal waters of Staro Hopovo are completely natural without any intervention done by men. Other waters are results of deep bores.

## Thermal and Mineral Water of Vrdnik

Vrdnik, a picturesque settlement in Fruška gora, is situated at the 200 m above-sea level on the slopes of the Vrdnik basin, only 34 km from Novi Sad. In 1996, it received a status of a spa resort because of its mineral water. The source of the mineral water is in the valley of the Vrdnik brook, upstream from the old Vrdnik colony. It was discovered by accident in 1953. In 1955, the Hygiene Institute of Sremska Mitrovica has performed capture. However, the source has been operating with interruptions. The maximal effusion gives 50 l/min. The water temperature is 15.5°C. The water is clear, acid and has weak odour of sulphur hydrogen.

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The thermal and mineral water that established the present features of this spa resort appeared completely accidentally in the southern shaft of the coal mine near Vrdnik. According to Milojević (1968) and Čučulić (1961) and the archives of the coal mine near Vrdnik, the southern shaft at the 245.22 m reached up 28.8 m. On that very point the water began to spring out and after several attempts to stop this, on October 5th 1931 at the same fourth horizon and at 29th metre of the eastern hall there was a major outbreak of water. The lime-stone was cut into this depth, which represented a great underwater static reservoir. The mine soon became flooded and water level was at about 22 m below the terrain.

The water has temperature of 30.7°C, it is clear, colourless, tasteless, and has H<sub>2</sub>S odour. It has been mineralized and according to the O. Alekin's classification it can be classified as hydrocarbon sulphate water belonging to sodium-magnesium group.

According to Petrović et al (1973), warm water of Vrdnik feeds itself from deep karst retentions. Its regime is conditioned by the system of inner canals which go below 300 m. Unlike other karst sources the karst-thermal spring in Vrdnik has extremely optimal abundance. This can be explained by the widely-spread canals and reservoirs fed from great retention reservoirs.

Present And Future Usage - In addition to thermal and mineral waters on this site, which were a basis for creating a balneological center, there are numerous natural and anthropogenic factors. The natural values include: microclimatic features with characteristics of air spa, good-quality and well-preserved woods and mountain meadows overgrown with meadow plants, important recreational, esthetic and attractive features, wild life which, according to the status of national parks, provides the development of highly selective hunting and photo-safari tourism. In the immediate and further away surroundings, there is a number of anthropogenic values, such as: the Ravanica monastery, the Vrdnik Tower dating from the 3rd century when Romans were there, smaller archeological sites, and Vrdnik town which has its own tourist qualities. Apart from its tourist attractiveness, it has receptive, communicative, infrastructural and superstructural bases which enable the transformation of this place into medical-balneological and recreational center. The resources upon which this center is based have high value and therefore if the reconstruction continues it will fulfil the opportunity to go beyond the borders of



Vrdnik spa

Srem and becomes a center of national importance.

One of the major disadvantages of the spa is disadvantageous tourist and geographic location. It is situated far away from major railroads (10 km from Novi Sad-Ruma road), and the quality of the local road is relatively low. Therefore its position can be made better only by the reconstructing local road according to modern standards.

First facilities consisting of three swimming pools: 36x12 m, 14x8 m and 10x2 m, were built in 1932 for medical and recreational purposes. The next bigger event was only in 1973 when the first Olympic pool was built with the improvised therapeutical center.

The water from the North shaft was directed to another basin by system of underground plumbs, so today it is used for recreation and bathing. For balneological purposes, the water is used within Vrdnik spa. Medical indications are:

1. Chronic and inflammatory rheumatism (chronic polyarthritis, Bahterel disease)
2. Extraarticular rheumatism (fibrositis, miositis, panniculitis).
3. Degenerative rheumatism (arthrosis, spondilosis)

Another source of thermal mineral water called Kisela can be used for medical purposes as an additional healer with the following chronic diseases: chronic stomach diseases, ulcer, post operation conditions, etc.

The existing thermal mineral waters in addition to complementary values, i.e. the total attractiveness of the area represent a basis for the development of this balneological center. Bigger and more various offer, specially for the demands of medical tourism indicate further research of the thermal and mineral water reserves, establishing indications and

contraindications and corresponding facilities for treatment and rehabilitation.

The spa's main function is medical and we can expect the greatest influx of money from it. That is why in 1981 they started a new therapeutical section that is a basis of future medical center. It consists of: surgery and reception with patient files, room for physiotherapy, room for acupuncture, ten compartments for electrotherapy, three compartments for paraffin therapy and rooms for X-rays. Thermal water is used in three special bathtubs for underwater massage, walking pool and pool of 5x6 m. Next to them are rooms for patients' relaxation and saunas. The buildings are connected with heated halls. Around this complex, there are terraces for sunbathing, parking lots, sports grounds, campsite and bungalows.

Tourist and catering company Fruška gora has once done many in terms of infrastructure, such as: adequate electric installation, plumbing, heating with boiler room and filter stations. They have also built internal system of roads, central change rooms for swimmers in outdoor pools and chemist's shops open to public.

The primary reception has been done in Hotel Termal, built in 1979, with capacity of 47 beds in single and double rooms and one suite. The dining area consists of a restaurant, a roofed over terrace with 1000 seats and aperitif bar. In 1980 an annex was built with 116 beds in single and double and suites. This part has got two indoor swimming pools - one 45x42 m and the other 22x15 m. The hotel also includes a congress hall with 600 seats. The hall can be divided in three parts for business meetings, scientific and professional gatherings and receptions or celebrations. The aim of building this place was to offer wider

range of facilities off-season and to instigate the development of extremely profitable congress tourism.

Along the edge of the valley there are private holiday houses for relaxation and recreation. The town planing predicts another 600 of such houses. There are possibilities of accommodating visitors in private homes as well. The conveniences satisfy tourist need.

Natural amenities with many attractive features have enabled the development of numerous facilities in infrastructure. More general infrastructure includes arranged green areas of 4,973 ha divided into two parks. One is in the center of Vrdnik and the other is a part of medical - recreational center.

So far holiday visitors have had priority to resident ones. Generally attractive base off Vrdnik and its surroundings has enabled the development of the following types of tourism: congress, event, country, hunting and selective types which are results of a tourist need to be in protected nature.

Evaluation of necessary factors for the development of tourism in Vrdnik shows that the greatest importance has been given to natural tourist values while the receptive base has been relatively neglected. Therefore, above all, the following should be done: renovation of receptive tourist area (hotels and restaurants), infrastructure (roads system and accompanying facilities, sports facilities, etc.), superstructure (facilities for organized cultural, entertaining and sports events, service companies, etc. In addition, the following assignments should be realized: improve certain aspects of tourist offer, create tourist programs selectively, i.e. adjust them to clients which come for medical reasons and the ones which are not interested in the medical part of the center, organize new events and promote the existing ones in a better way, create new and more aggressive marketing presentation and establish local tourist organization.

## Thermal and Mineral Water of Stari Slankamen

Stari Slankamen has been built at the north-eastern part of Fruška Gora, just under the high loess cleavage near the right bank of the Danube. It is connected by local road (9 km) with international highway Belgrade-Novi Sad- Horgoš, Hungarian border, and via Novi Karlovci with Indjija (19 km) and international highway E-5. As it has been mentioned, the spa has been famous since Turkish period. The first scientific analysis was done in 1899 and repeated in 1922. The analysis was done in the old well, which is still used today. It was established that

the water contained  $\text{CH}_4$  and  $\text{CO}_2$  gases. In 1952 and 1953, six new wells were dug up. Mineral water was obtained only from the C-5 well. According to the initial analysis, mineral water belongs to saline iodine waters of Chloride and Sodium type with mineralization of 6, 852g/l.

The origin of the mineral water (Milojević and Spirić, 1964) is explained by the metamorphosis of the fossil seawater with infiltration waters. It originates from the strata of Second Mediterranean, which contain salt water in the entire Vojvodina and are part of structure which are rich in oil and gas.

Present and Prospective Usage - According to Laškov (1984) the mineral source called Slanača in Stari Slankamen, which nowadays is a shallow dug well, was found in 17th century by the Turks. In description of Slankamen from 1702, the following is mentioned: "a well built Turkish spa and a spring that produces salt healing water".

Thermal and mineral water and the accompanying health center are a basis for the possibilities of maximal consumption of natural and anthropogenic tourist resources, for building material basis and activating organizational factors, in order to enrich tourist offer. Thus we can create a medical and balneological center but also a sports and recreational center.

By establishing the non-existing passenger traffic on the Yugoslav part of the Danube we could reactivate the possibilities for reaching the spa by river as it used to be before. This location satisfies the criteria for nautical center - convenient tourist and geographic location, natural, cultural and historical amenities, closeness to disperse center with developed types of tourist demand, satisfactory ecological criteria, etc.

Thermal and mineral waters with their thermal and chemical properties have healing features and therefore we should rebuilt, reconstruct and construct new segments of material base, which will enable optimal functioning of medical and balneological tourism.

Thermal and mineral water of Stari Slankamen is today used as part of the treatment as the Institute of physical medicine and rehabilitation, Belgrade. This building has characteristics of a medical center, i.e. the Institute for prevention, treatment and rehabilitation of neurological diseases, specializing in treatment of central paralysis (hemiplegia and paraplegia). They also treat post-traumatic and post-operational conditions. Iodine muriatic water is also used for treatment of various rheumatic diseases, lumbago etc.

The following treatments are used: kinesotherapy, working therapy and hydrotherapy (in the swimming pool for in-patients and in 15 bathtubs for out-patients). Considering the properties of water it has been indicated that the center should further specialize in the treatment of hemiplegic diseases, which suggests further reconstruction and adaptation of the existing facilities that can be used for that purpose.

The surroundings offers cultural and historical amenities, such as the remains of a city dating from the Middle Ages situated on the site of the ancient city Acuminum (2nd century), Saint Nicolas Church with frescoes from the 15th century, a monument commemorating Serbian and Austrian victory over Turks from 1861, etc.

Reception buildings have been degraded in comparison to the situation in the 1960s when they consisted of three hotels and restaurants. One of the reasons is the treatment of Stari Slankamen exclusively as a medical center. Hotels have lost their status and gained characteristics of stationary centers with accommodation, food and beverage services only for patients. Later on, an Institution for Neurological Diseases Dr Borivoje Gnjatić has been built as part of an Institute of physical medicine and rehabilitation, Serbia. The Institution is situated in a building with modern facilities on the left bank of the Danube. According to its exterior and Interior it has characteristics of a hotel establishment, which has a positive psychological influence on patients, because they have a feeling of being in a hotel and not in hospital.

For this site, Laškov often states that it represents the most attractive part of the Danube from Novi Sad to Djerdap. This should certainly be taken into account, above all, in order to optimize the usage of thermal and mineral waters as a unique tourist resource, and for development of medical and recreational and cultural movement.

Microclimatic conditions are more suitable than the rest of lower parts of Vojvodina (100). On one hand, it is because of forest area, and on the other because of water mass of the Danube. The experts also estimated that patients benefit from the airflow in the river valley during the unpleasant summer drafts in the lowland. What is also convenient for the development of medical and balneological tourism is the location of this area in the harmonious natural surroundings, which has sedative effect on men.

General conditions for the development of spa tourism are good, but they need modernization of hotels, facilities



for therapy, infrastructure and superstructure, and bigger involvement of organizational factors.

Nautical reception facilities, such as ports, should be built for nautical tourism. Technical requirements are satisfied since in the 1960s there was a port in this area with great circulation of liners, one of the reasons being nearness of the Tisa and Danube estuary.

Since this center awaits further development, there is a possibility to separate part of the area for medical tourism and the one aimed at visitors coming because of recreational reasons. This creates opportunities to satisfy individual features of these forms of tourism which are contradictory and whose interaction can be counterproductive. Separate area would include the usage of thermal and mineral water for building indoors Olympic swimming pool, but also a beach near the Danube, sports and recreational ground, parks, walking areas, with various amenities, service for sports and tourist activities, cultural public places, etc.

Fishing and angling have long tradition in this area. If this part of tourist offer is enriched by adaptation and building of infrastructure and superstructure it will enable offering a selection of fishing and angling equipment.

## Thermal and Mineral Water of Ljuba

Ljuba is a small settlement in Fruška gora located in its western part, 36 km from Novi Sad. Its geografic position is excentric along the border with Croatia. The spring Banja is in a smaller stone pit where lime stone has been exploited. Thermal waters have always been known of (Kochu, 1896) and even in Turkish times ther was a spa near Ljuba.

Old springs form Turkish period have been abandoned. Productivity fluctuates and ranges from 3 to 6 L/s. According to the above table water is  $\text{HCO}_3^-$  - Ca, Mg type, total mineralization 0,73 g/l. Radioactivity is minimal and is as follows:  $\text{Rn}2$ , 84Bq/l,  $\text{Ra}$ -o, 12 Bq/l,  $\text{U}$ -0,001 mg/l.

Present and Future Usage - The thermal and mineral waters can be used if swimming pool is built mainly for recreational purposes as a part of the surroundings which have two lake accumulations near Erdevik and Berkasovo. It is situated close to the borders of a national park wit recreational, esthetic and extraordinary tourist values. Complementary to these values are monasteries Djipša and Berkasovo. The narrowest contract zone of this location is [id, while in the daily and weekend con-

tract zones are Novi Sad, Sremska Mitrovica and Ruma. A general survey shows that thermal and mineral springs of Ljuba should be included in recreational segments of tourist offer of Fruška gora.

## Thermal and Mineral Water of Kupinovo

Kupinovo, a peaceful village in Srem, has been built at its far north, near the left bank of Sava. In 1972, there was built a well 450 m in depth for the local water supply. During the drilling on 351-358 m hot watter apeared with 38°Celsius and total mineralization of 1,0 g/l. Productivity was 3,51 l/s. Water was of the  $\text{HCO}_3^-$  -  $\text{SO}_4$  type (Dimitrijević, 1975).

Present and Prospective Usage - Balneological investigation was done in 1987 and it was established that the water can be used as a part of the balneological and therapeutical rehabilitation and bathing if cooled to a required temperature for the following: locomotive apparatus, fractures and surgical operation of the skeleton system.

In 1985 they made another well for the geothermal needs, maximal depth 644 m. At that time they found Triassic lime stone. Water temperature was 51°C, and productivity 25 l/s.

Absolute age of the water, according to the isotopic investigation of samples was 8000 (plus-minus 200 years). Radioactive content is low:  $\text{Rn}$ -4, 1 Bq/l,  $\text{Ra}$ -0,09 Bq/l,  $\text{U}$ -0,0001 mg/l (Protić, 1995).

Usage of geothermal waters near Kupinovo for medical and balneological or sports and recreational purposes should be analyzed in context of their tourist location, i.e. according to its immediate nearness to such natural tourist values, such as; Obedska bara, river Sava and anthropogenic values - mainly ethnographic and archeological sites. Considering the attractiveness of these amenities, it is possible to use geothermal water in addition to them and thus create relatively rich and various tourist offers. It is necessary to develop tourist reception and communication areas. Consequently this area should gain better possibilities for tourist activation in comparison to earlier and present conditions which are characterized by partial and bad quality offer.

The offer should be a system of events, processes and connections typical for tourism in protective nature (Obedska bra), medical and balneological tourism (smaller health center with facilities for treatments in thermal and mineral waters and accompanying equipment), recreational tourism (indoor and outdoor pools) and because of geothermal waters fishing tourism based on plant

communities in alluvial plain near Save. In addition, free individual and group visits to a museum, which could contain archives about Obedska bara and objects of archeological character, ethnopark, and also presentations of specific geographical environment.

## Thermal and Mineral Water Near Staro Hopovo Monastery

Hot spring near Staro Hopovo monastery is within the bed of Lipov potok (Lipa's Brook) 200 m from the monastery. The spring is situated on the contact of Paleozoic slate and magmatic rocks. Productivity is 0,3 l/s, water temperature 18,5°C. Water belongs to  $\text{HC}_3$ ,  $\text{SO}_4$  - Mg, Na, containing free  $\text{H}_2\text{S}$  up to 3,5 mg/l (Petrović et al, 1973). Water is used only by local population. It is thought it has healing effects. It is certain that this area is very interesting because its geologic structure and geomorphologic forms and it needs detailed scientific and professional investigation. It would be no surprise if there would be found another important thermal and mineral site in Vojvodina. Only after this investigation is performed we can talk about possible usage of the waters.

## Other Perspective Sites of Thermal and Mineral Water

During the investigations of oil, gas and geothermal energy on several locations in Srem, there have been found thermal waters with good perspectives. In Indjija a well was built in 1989 going down to 750 m. On the depth of 635 m, hot water of 62°C was found with capacity of 0,5 l/s. In Budjanovci water was found on 440 m, temperate 35°C, in Sremska Mitrovica on 400 m, temperature 27°C and the second round of drilling in Srem discovered significant amounts of thermal and mineral water.

## Other Possible Forms of Usage

Apart from the above mention usage which are most completely realized in Institutions for medical rehabilitation Termal Vrdnik and Stari Slankamen, it is possible to use these waters in different ways.

Usage in Agriculture - Depending on the capacity of the wells, their temperature, chemical content, it is needed to determine potential users. The experimental centers should be organized and according to the obtained results, it is possible to suggest the development of programs to exploit the water. Accordingly, the production of certain plant, especially vegetables in green houses

and farms should be grouped around certain sites. This type of usage in Srem, which is an agricultural area with great reserves of thermal and mineral water, opens various possibilities and a number of competent experts claim that these possibilities overcome other Pannonian parts of Yugoslavia.

For agriculture, it is possible to use waters of lowest mineralization, because of eventual possibilities of inconvenient influence of large amounts of salt to arid soil, etc. For optimal growth of plants, during irrigation, the water should be from 20 to 30°C. In order to achieve this temperature, thermal water should be 30 or 40°C when springing out because when it comes in contact with soil its temperature will decrease in about 10°. At the same time it is necessary to say that the lowest content of mineralization is present in the waters of the South Srem and they are the best for massive usage in agriculture.

Ideal green houses need to be heated with geothermal water. This is the most usual way of growing tomatoes, cucumbers, and other vegetable and flower species such as peppers, melons, watermelons, green salads, chrysanthemum and for growing seedlings. In this situation we can apply so called multiple cascade usage which means the water is used for heating the greenhouses with cucumbers and tomatoes and then is taken through the system of plumbs to the open area with different vegetables (Milivojević, Martinović, 1996).

Aquaculture involves breeding water organisms in regulate environment in order to increase productivity. The most usual species are catfish, perch and sturgeon. Temperature of water in such fishpond depends on the type of fish. For aquaculture geothermal water is more important than for cattle raising because water organisms are more sensitive on the changes of water temperature than continental animals. If we use waters of optimal temperatures their productivity will be higher.

For heating indoors, we can have classical system of heating if we use water whose temperature is between 75 and 90°C. Water whose temperature is 50-70° is used in the system of floor, air and combined heating; temperature between 40 and 60° can be used in hot pumps, which requires further expenses for waters that cannot be used directly. This is the most frequent type of water in Srem (Janković, Belić, 1996). Its chemical content has to be convenient, i.e. should not have negative effects on the distribution system.

The best possibilities for installing such heating system are in Sremska Mitrovica

from the area of Mačva where there is a double system with Geothermal Heating Company in Bogatić. In addition to this town, this kind of heating can be provided for [abac and Loznica. Water temperature in the heating system should be maintained on the 65/45°C level. Second step is to use side products of heating with temperature lowered on 45 - 50°C. It would be transported through plumbing system and used for heating greenhouses, farms, sports and recreational swimming pools and aquaculture. It is believed that in this phase the temperature would be lowered from 45° to 15°C and would continue to flow through another system of plumbs to the injection well where it would be absorbed into the soil and reheated (Milivojević et al, 1996). To fulfil this project, especially for Sremska Mitrovica, it would be more important to establish the existence of such waters at the south of Srem. Usage of geothermal energy is important from the ecological aspect because it would decrease the pollution of this town, which is famous for having big polluters of the environment, such as a factory for manufacturing of woods and production of cellulose Matroz.

Experts evaluation shows that it would be possible to solve specific problem during the construction of this system, and that the project could be realized with local experts and technology.

Another possibility is the usage of geothermal water in seeds industry for drying seeds after harvest, drying healing plants, fruit, vegetables in cattle raising for the heating of stables, as technological water in agriculture, etc.

## References

- Aksin, V. i drugi (1976): Mineralne i termalne vode Vojvodine i mogućnosti korišćenja, Fond "Naftagasa", I i II deo, Novi Sad.
- Aksin, V. i drugi (1984): Neki vidovi korišćenja geotermalne energije u SAP Vojvodini, Zbornik radova VIII jugoslovenskog simpozijuma o hidrologiji, i inženjerskoj geologiji, Budva.
- Bogdanović, Ž. (1982): Hidrološki problemi Srema, Doktorska disertacija Prirodno-matematički fakultet, Institut za geografiju, Novi Sad.
- Čičulić, M. (1961): Razvoj vrdničkog ugljenog basena, Vesnik, Zavod za geološka i geofizička istraživanja, knj. XIX, serija A, Beograd.
- Dimitrijević, N. (1975): Gasovi u podzemnim vodama posebnim osvrtom na njihovo prisustvo u mineralnim vodama Srbije, Zbornik Rudarsko-geološkog fakulteta u Beogradu, Posebno izdanje, knj.3, Beograd.

Janković, Z., Belić, S. (1996): Mogućnost korišćenja geotermalnih voda u Vojvodini, Ecologica, Mineralne, termalne i izvorske vode, istraživanje, primena, zaštita. Zbornik referata i zaključaka I Nučno-stručnog skupa (Arandjelovac, 1996), Udruženje proizvođača mineralnih voda Jugoslavije, DD, Beograd, strana 269-274.

Laškov, M. (1982): Banjski turizam SAP Vojvodine, Prirodno-matematički fakultet, Institut za geografiju, Novi Sad.

Milivojević, M., Martinović, M. (1996): Korišćenje geotermalnih resursa u svetu, Ecologica, Mineralne, termalne i izvorske vode, istraživanje, primena, zaštita. Zbornik referata i zaključaka I Nučno-stručnog skupa (Arandjelovac, 1996), Udruženje proizvođača mineralnih voda Jugoslavije, DD, Beograd, strana 147-169.

Milivojević, M. i drugi (1996): Idejno rešenje kompleksnog integralnog korišćenja geotermalnih resursa Mačve, Ecologica, Mineralne, termalne i izvorske vode, istraživanje, primena, zaštita. Zbornik referata i zaključaka I Nučno-stručnog skupa (Arandjelovac, 1996), Udruženje proizvođača mineralnih voda Jugoslavije, DD, Beograd, strana 305-311.

Milojević, N. (1952): Prilog za poznavanje hidroloških prilika u Starom Slankamenu, Geološki anali Balkanskog poluostrva, Beograd.

Milojević, N. (1976): Hidrologija Fruške gore sa hidrogeološkom kartom, Vode Vojvodine, Godišnjak pokrajinskog fonda voda, br. 4, Novi Sad

Milojević, N. i drugi (1968): Uticaj sifonalne cirkulacije u proces karstifikacije u vrdničkom basenu, SAN-u Cvijićev zbornik, Odeljenje za prirodne nauke, Beograd.

Milivojević, N., Spirić, J. (1963): Hidrohemijske karakteristike i hidrohemijski režimi podzemnih voda u Vojvodini, Zbornik Matice srpske, serija za prirodne nauke, sv. 25, Novi Sad.

Petrović, J. i drugi (1973): Vode Fruške gore, Posebno izdanje Matice srpske, Novi Sad.

Protić, D. (1995): Mineralne i termalne vode Srbije, Geoinstitut, Posebno izdanje, Knj. 17, Beograd.

Stojić, M. (1968): Pojava suvišnih unutrašnjih voda u ravničarskom delu Vojvodine, Vodoprivredni glasnik NR Srbije, Sv. 51-54, Novi Sad.

Tomić, P. (1977): Vodosaobnavljanje stanovništva i industrije u SAP Vojvodini, Doktorska disertacija, manuscript.