

THERMAL WATERS AND BALNEOLOGY IN BULGARIA

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INTRODUCTION

Bulgaria has a variety of mineral waters with temperatures up to 100°C. Thermal waters with high alkalinity and low level of TDS are predominant. The country is situated at the southern part of the Balkan Peninsula and is an heir of ancient civilizations.

There are extremely good bio-climatic resources which combined with the existing ancient Mediterranean traditions in thermal water use, provide a base for the balneological development in the country. A number of large spa resorts have developed in places of old Thracian or Roman residential areas, like: Sandanski, Kjusten-dil, Hisarja, Velingrad, Sapareva Banja, etc. Even the capital city of Bulgaria, Sofia, was established close to thermal springs with temperature interval of 20°C-50°C, by Thracian tribes in third century BC.

The most active development of our spa system is in the time period of 1970-1980. Until 1990, about 40 resorts of local and national significance were actively operating in Bulgaria. In these spas, a wide range of diseases are treated using scientific methods and programs, confirmed by a long-term professional experience.

The economical and social changes in our country during the transition period towards the free market economy led to a drastic decrease in the governmental subsidies for balneology, and to a deterioration of some of the resorts and even to a closure of some. The Bulgarian spas are under the Ministry of Health governance, and their sponsoring, management and exploitation will be done according to the new laws and regulations in the country.

In most Bulgarian spas, the thermal waters are not used to their fullest potential. This is especially true in the case of high temperature reservoirs ($T > 70^{\circ}\text{C}$); where, the water is left in open tanks to cool down to the desired temperature or is mixed with expensive cold tap water. In this way, the water's mineral composition has been changed and its healing agents have been diminished. At the same time, the buildings are heated with conventional fossil fuel boilers, usually coal or oil. This gives a situation of reduced efficiency of the mineral application, wasted energy and locally polluted environment.

Up until the 1980, thermal water was only partially used for health and recreational bathing, washing, swimming pools, greenhouses, bottling of potable water and soft drinks production, derivatives, etc.

After the 1980s, modern systems for space heating, air conditioning and ventilation, indoor and outdoor swimming pools have been constructed. Most of the geothermal

stations have been build on reservoirs of low temperature (40°C - 60°C) which prevail in our country. These systems are indirect ones and are assisted by plate heat exchangers and heat pumps. The total installed capacity of the geothermal systems in Bulgaria is 95.35 MWt.

The construction of new cascaded geothermal systems at these sites will considerably improve the efficiency of the medical treatment, improve the local air quality and significantly reduce the use of fossil fuels.

CONDITIONS FOR SPA DEVELOPMENT IN BULGARIA

Bulgaria covers 111,000 sq km and there is an extraordinary combination of factors providing perfect conditions for tourism, healing and recreation. The abundance of thermal waters, their variety and purity, the moderate to transcontinental climate and the Mediterranean influence as well as the national traditions in thermal water healing in Bulgaria, are prerequisites for effective and complete use of our natural resources.

Thermal Waters

The mineral waters are one of the most precious natural resources in Bulgaria. There are more than 500 hydrothermal sources with a total flow rate of 3000 L/s, having different temperature and mineral composition. Almost all of them are thermal as the temperature varies in a wide range from 20°C to 100°C . About 33 % of the total discovered flow rate is of temperature between 20°C - 30°C , and 43%-between 40°C - 60°C (Petrov, et al., 1998) (Figure 1).

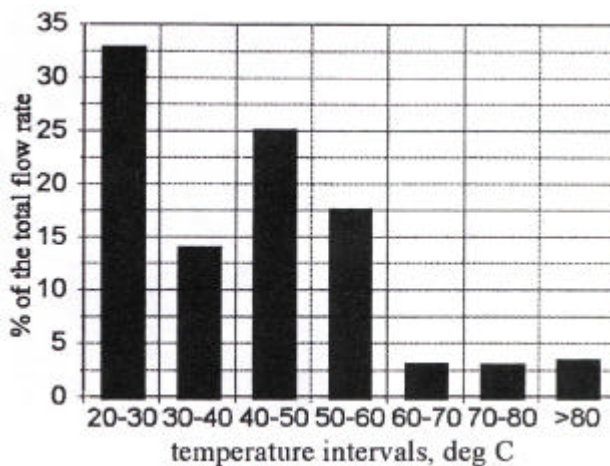


Figure 1.

Flow rate distribution (in %) for temperature intervals.

About 70% of the thermal waters are slightly mineralized with fluoride concentration ranging from 0.1 to 17mg/L, various metasilicic acid concentration (up to 230 mg/L) and of mostly low alkalinity. In comparison to most of the European mineral waters, the Bulgarian ones have a lot of advantages: low TDS close to the optimal one typical for potable water, high purity level especially in terms of anthropological pollution, microbiological purity and a variety of water types (Vladeva and Karakolev, 1996).

Mineral waters in spa centers at most of the sites, flow out of taps. This allows a free-of-charge and massive water use for drinking and disease prevention. In the capital city area alone, there are six mineral water springs provided by fountains.

Climate

Considering the small area of the country, its climate is very diverse: from moderate to transcontinental, with Mediterranean influence from the south and local Black Sea influence from the east. The spa centers in Bulgaria are usually placed in mountain tourist resorts and some are at the seaside. The elevation varies over a wide range (from the sea level up to 800 m) and this satisfies the specific needs of the patients and provides good conditions for treatment. In most of the healing centers, there are year-long activities: disease prevention, treatment and rehabilitation.

Balneological Tradition

In our largest spa centers, there are data about using thermal waters both for healing and heating in the Roman baths from the I-IV century AC. These uses continue, and in addition, the literature records show that these baths were also social centers.

Until 1990, all spa centers were included in the health care system and received regular governmental subsidies. At the moment, privatization and reconstruction processes are taking place in all of these centers.

Highly experienced specialists are working in our spas. They offer treatment of a wide range of malfunctions and diseases such as: chronic respiratory malfunctions, locomotory system problems; peripheral nervous system diseases; digestive system, gynecological and kidney diseases; chronic intoxication problems, etc. (Karakolev, 1984). The treatment includes the use of mineral water drinking in prescribed doses depending on its composition. Water is used for healing baths in tubs, showers, pools, as well as for inhalation (mixed with herbs or other medications), irrigation, etc. This treatment is combined with other physiotherapeutic or rehabilitation procedures, such as sun baths, etc.

The wide spread of thermal waters therapy allows using an outpatient treatment that keeps the patients' every day routine unchanged: one goes to work and comes for treatment during suitable day hours. There are a lot of beaches created around indoor and outdoor geothermal pools, and this improves the prevention of many diseases.

SPA CENTERS IN BULGARIA

The spa centers in Bulgaria are of local and national significance and most of them are situated in South Bulgaria, Figure 2.

Seven national resorts are presented in more details. They have been selected for several reasons: well-developed base for treatment, large tourist centers and good prospects for further development under the new free market policy in the country.



Figure 2. Location map of spas of national significance.



Figure 3. *Thermal bath (built in 1912).*



Figure 4. *A sanatorium, heated with geothermal energy.*

THE TOWN OF KJUSTENDIL

The town of Kjustendil (50,000 residents) (Figure 2) is built on the place of the famous ancient Roman town of Poutalia. It prospered in the I century during the Roman rule when impressive balneotherapeutic “temples” were built, being the second in size on the Balkan Peninsula. The town is at the foot of the Ossogovo Mountain at an elevation of 530-550 m and there is a good communication system between Kjustendil and Sofia, Greece, and Macedonia in terms of railways and bus transport. In 1910, the water of forty mineral springs was captured in a common shaft. The total flow rate is 33 L/s and its temperature is 71.5°-74.8°C. The balneological complex is in the center of the town and has been in operation since 1966.

Chemical Composition

Most of the thermal waters in the region are slightly mineralized and are of wide temperature range. The TDS values are within 0.276 to 0.920 g/L. The waters are hydrocarbonic-sulphate-sodium or only hydrocarbonic-sodium ones.

The mineral water tests done in Kjustendil region show a constant physical-chemical water composition, and stable characteristics in terms of mineral content. An additional advantage is that this water meets the existing European sanitary and chemical criteria for level of purity.

There is a big curative peat deposit in the vicinity of the spa rich in biologically active substances and humid acids. The combination of different natural factors in the same region creates exclusive opportunities for a versatile, complete and wide application of all of them.

Healing Indicators

The climate in Kjustendil is transcontinental with a Mediterranean influence. The summer there is long and warm, the winter is mild and short, and autumn is long and warm. The mean annual air temperature is +10.9°C, the mean January one is (-0.6°C), and the mean July temperature is +21.6°C.

The presence of hydrogen sulphide, hydro-sulphide and sulphide in the mineral water in Kjustendil and Sapareva Banja make them very useful in bone joints treatment, peripheral nervous system, gynecological malfunctions cure, healing of chronic lead based intoxication, etc. These waters might also be used in prophylactic treatment of osteoporosis, over dose radiation based malfunctions, fluoride based caries prevention, etc.

Thermal Water Application

The existing geothermal station is of 1.250 MWt installed capacity and provides space heating and domestic hot water to one sanatorium (Figure 4). Two outdoor mineral water pools are built in the town.

There are favorable conditions for construction of a new integral system for complex geothermal energy utilization. This system is going to provide space heating, air conditioning, and domestic hot water to the whole balneological complex: the polyclinic, sanatoriums, public baths, etc. The new system capacity has been estimated to be about 5 MWt.

The thermal water from well 2 Nevestino (about 10 km away from Kjustendil) is used for bottling of potable mineral water. There is an optimal fluoride ion concentration (1.0 to 1.2 mg/L) in it and the produced quantities are both for local market and export.

THE TOWN OF SAPAREVA BANJA

Sapareva Banja (9,000 residents) is a mountain resort and it is one of the largest balneological centers in Bulgaria, (Figure 2.) Ancient relics from the Thracian settlement of Djermaneja founded in I-II century BC have been found there. The town is situated in Southwest Bulgaria in a valley between two Alpine mountains – Rila and Pirin, at an elevation of 745 m. There is a bus transport between Sapareva Banja and Sofia (at a distance of only 60 km) as well as to Greece.

The highest temperature for the country thermal water of 101°C has been recorded here. The local water temperature in the springs varies from 60°C to 86°C. At present just one well is producing and is self flowing; with a temperature is 97°C-98°C and flow rate of 16 L/s, (Figure 5).



Figure 5. *Well 4 (The Geysir) in Sapareva Banja town.*

Chemical Composition

In this region, the water chemical composition is similar to the waters in Kjustendil. The TDS is 0.69 g/L and the pH is 9.14. The water purity level meets the existing sanitary and chemical criteria.

Healing Indicators

The climate in Sapareva Banja is transcontinental with some Mediterranean influence. The mean annual air temperature is +10.6°C. The mean temperature in January is (– 0.7°C), and in July is +20.2°C. The existing spa center consists of a sanatorium (Figure 6), having three departments: polyclinic, building of medical surgery and canteen, and outdoor mineral water pool.



Figure 6. *A sanatorium heated with geothermal energy.*

Locomotory system and gynecological diseases as well as peripheral nervous system disorders and chronic heavy metal poisoning malfunctions are treated there. The center has over 200 beds for extended patients stay and provides for thousands of outpatients.

Thermal Water Application

The balneological center and the geothermal station were both built in the period of 1954 – 1962. The total installed capacity of the geothermal station is 0.250 MWt and it provides space heating and domestic hot water for the balneological center as well as for greenhouses and a public bath. A new installation was set up in 1997 in the building with medical surgeries and a canteen. The building was chosen for a demonstration site as a part of the project: “Technical and Economic Assessment of Bulgarian Renewable Energy Resources,” PHARE Project, 1997

A Bulgarian team of experts presented a project for a new modern geothermal district heating system (of about 11 MWt installed capacity) for 14 downtown buildings in Sapareva Banja (Bojadgieva, et al., 1999).

Many international organizations are interested in Sapareva Banja in relation to the development of a complex center of balneology, tourism and thermal water application.

THE TOWN OF SANDANSKI



Figure 7. *Sandanski spa hotel.*

The town of Sandanski (32,000 residents) is a famous climato-balneological center (Figure 2). It is situated at the foot of the Alpine Pirin Mountain near the river Sandanska Bistritca. There is bus and railway transport between Sandanski and Sofia, Greece and Macedonia.

The waters from the Sandanski area were even used in II millennium BC by the Thracian tribe “Medi.” During the Roman and Medieval ages, the spa center prospered as can be seen from the temple-bath remains. There are more than 20 springs in the resort. The waters have a temperature ranging between 35°C-83°C and total flow rate of 19 L/s.

Chemical Composition

This region is characterized by a variety of waters of different temperatures and chemical composition. The mineral waters are silicic, mildly fluorine, hydrocarbonic-sulphate-sodium-calcium and have a neutral to mild alkaline reaction with pH of 7.6 -9.0.

From the sanitary point of view the water is unpolluted. The physical-chemical thermal water composition and properties are stable for the region.

Healing Indicators

The climate of Sandanski is Trans-Mediterranean. The mean annual air temperature is +13.9°C; the mean January temperature is +2.4°C and mean July is +24.6°C. Sandanski boasts the mildest climate in Bulgaria, the greatest sunny days per annum (2440 hours of sunshine) and the lowest humidity - 66%. All chronic conditions of respiratory tract and bronchial asthma are successfully treated here. The combined climatic and balneological factors give good results in locomotory system diseases, peripheral nervous system and digestive disorders, some kidney disease, skin or allergic problems, and acute bone-joint rheumatism attack treatments.

The set of treatment and prophylactic methods, used in Sandanski resort, are of great interest. For instance, sun and air baths, climatic influence combined with specially designed walking routes, respiratory directed gymnastics, acupuncture, mineral water mixed with herbs (or medications) for inhalation procedures are often used. Hydro-therapy like underwater gymnastics, swimming in indoor and outdoor mineral water pools, electrical and light healing procedures, healing massages, special food diets, apitherapy using bee products, and sauna give fantastic results.

Thermal Water Application

The existing geothermal station is in use all year. It provides space heating, domestic hot water, air conditioning and ventilation for a vacation complex and is of 2.1 MWt installed capacity. An underfloor heating system is constructed in the building.

THE TOWN OF VELINGRAD



Figure 8. *A view from the town of Velingrad.*



Figure 9. *A sculptural composition of the thermal water image.*

Velingrad is well known for its beautiful surroundings and excellent mineral springs, located in Figure 2. Roman baths and water supply system remains are found here.

The town of Velingrad is situated on the west side of the picturesque mountain Rhodopes at 750-780 m elevation. There are over 70 hot mineral water springs on the town territory of 132 L/s total flow rate.

Chemical Composition

The mineral water varies considerably in temperature, mineral content, radon, silicic acid and fluorine content. There are well-defined water temperature and chemical zones in the town of Velingrad. From south (Chepino suburb) to north (Kametitca suburb) the mineral water temperature increases (from 20°C to 95°C), the quantity of the dissolved salts increases (from 0.21 to 0.75 g/L), as well as the quantity of fluoride (from 3.6 to 10 mg/L), and silicic acid (from 36 to 129 mg/L). The water in Chepino and Kamenitca suburbs is of a higher radioactivity. The presence of radon (1.8 nC/l) and hydrogen sulphide (1.2 mg/L) improves the healing properties of the mineral water in Kamenitca suburb.

The mineral water in Velingrad is sulphate-hydrocarbonic-sodium-fluoride-silicic type. It is unpolluted according to the sanitary and chemical criteria.

Healing Indicators

The extremely favorable climate of Velingrad combined with the Mediterranean influence provides good opportunity of applying the climatic- and balneotherapeutic programs all year. The mean annual air temperature is +9°C; the mean temperature in January is (- 1.8°C), and in July is +18.8°C. The sunny period is significant, over 2000 hours in a year. The summer is mildly warm and the winter is mildly cold, the autumn is warmer than the spring.

The combined climatic and balneological treatment is recommended for patients having chronic respiratory system disorders. There are very good results in the

treatment of patients with locomotory system and neurological diseases. The gynecological malfunctions are of a special priority in the balneo-therapeutic list of this region. Velingrad spa serves as a prophylactic center as well. There is a well-developed balneological center with modern sanatoriums and hotels, operating all year.

Thermal Water Application

Geothermal energy is used for space heating of two buildings – a Youth Club and a school (Chepino suburb). The installed capacity is 0.150 MWt and 0.900 MWt, respectively. Mineral water is widely used in outdoor and indoor pools, greenhouses and public water taps. Since 1999, the mineral water from Chepino suburb has been bottled for sale in the country and abroad.

THE TOWN OF DEVIN

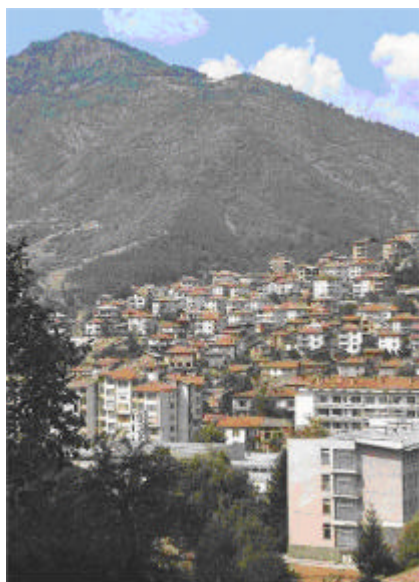


Figure 10. *A view from the town of Devin.*



Figure 11. *The rehabilitation hall.*

The town of Devin (7000 residents) is located on the East Rhodopes at 710-780 m elevation, located in Figure 2. The clear Devin River passes through the town. Besides its picturesque placement, the Devin region is well

known for its mineral waters that were discovered by drilling deep wells. Their temperature varies from 37°C to 44 °C and the total flow rate is 18 L/s.

Chemical Composition

The TDS values are low (from 0.29 to 0.37 g/L), hydrocarbonic and sodium ions prevail, along with limited quantities of chlorides and sulfides. The fluoride ions (from 1.8 to 7.7mg/L) are also found in the composition. The hydrogen sulphide presence is very useful for external balneotherapy.

Healing Indicators

The climate in Devin is transcontinental and upland. Its main characteristic is a warm but not hot summer and a warm, sunny autumn. The mean annual air temperature is +10.5°C, the mean January one is (-1.5°C), and the mean July is +16°C. This creates suitable conditions for both summer and winter tourism as well as for climatic treatment and prophylactic. The main diseases recommended for treatment by this mineral water are as follows: degenerative joint diseases of the locomotory system; nervous system functional disorders as well as mental ones; overweight problems, etc. This mineral water is suitable for prophylactics and recreation procedures in cases of physical and mental overstrain; post operational rehabilitation; for advanced aging prevention; for fluoride caries prevention; for radioactive overdose exposure healing and osteoporosis treatment.

Thermal Water Application

A new modern mineral water bottling factory of 5,000,000 liters monthly has been recently opened in Devin. In addition to local sale, these mineral water bottles are exported to Kosovo and are going to be exported to Germany and some Arabs countries.

THE TOWN OF HISARJA

The town of Hisarja (15,000 residents) is one of the largest spa known since ancient times, located in Figure 2. It is situated in South Bulgaria at the foot of the Sredna Gora Mountain at 364 m of elevation, close to the Valley of Roses. There are 22 mineral water sources with a total flow rate of 35 L/s and temperature of 27°C - 52°C in this area.

Chemical Composition

There are a unique variety of mineral waters of high content of some chemical elements such as calcium (from 3 to 21 mg/L) and sulphate (from 17 to 45 mg/L). The mineral water in Hisarja is famous for its radon content. Its highest concentration has been measured in the spring “Momina banja”-180 emans (666 Bq/L) and the lowest - in “Chuludja”- 30 emans (111 Bq/L).

This composition is combined with very low TDS of 0.256 g/L in a wide temperature range. The mineral water in this region is of hydrocarbonic- sulphate- sodium - silicic type, of high alkaline reaction (pH from 8.3 to 9.02) and is extremely pure.



Figure 12. *Ruins of an ancient Roman fortress (Hisarja town).*



Figure 13 *Thermal water fountain (Hisarja town).*

Healing Indicators

The spa climate is both sub-mountain and plain one with Mediterranean influence. The mean annual air temperature is $+11.9^{\circ}\text{C}$, the mean July temperature is $+23^{\circ}\text{C}$, and the mean January one is $+0.4^{\circ}\text{C}$. The summer is very warm to hot, the winter is mild, the spring comes early, and the autumn is long and sunny.

This water is excellent for people suffering from kidney, liver, gall bladder and digestive systems problems. Hisarja is also very suitable resort for prophylactic of osteoporosis through the complex balneophysical therapy leading to general body fitness.

Thermal Water Application

A geothermal station of 0.260 MWt installed capacity has been built in Hisarja. It provides space heating and domestic hot water for a sanatorium. There is an underfloor heating system constructed in the building.

Water from several sources (wells number 3 and 7, "Choban Cheshma," etc.) is used for bottling and sale to the local market.

BLACK SEA RESORTS

In the North Black Sea region, there is a unique combination of sea resorts and spa centers for healing and prophylactic. The thermal sources (wells) are located very close to the seashore and there are mineral water seeps on the beach. The geothermal pools (outdoor and indoor) are also placed close to the beach. Some modern international resorts are located here, for example: Varna city, The Golden Sands, Riviera, St. Constantine and Elena, and Albena (Figure 2). The attractive combination of sea water baths with mud baths and mineral water baths, as well as the geothermal energy application, makes the resorts operation very effective all year.



Figure 14. *Center of balneo-therapy (Albena resort).*



Figure 15. *Outdoor geothermal pool (Albena resort).*

The thermal water temperature decreases within the region from south to north as in Varna city it is 52°C (of 22 L/s flow rate), in "St. Constantine and Elena" - 48°C (of 43 L/s flow rate), and to the north in Albena it becomes 30°C (of 6 L/s flow rate).

Chemical Composition

The TDS is very low in these resorts and varies within a small range from 0.611 to 0.673 g/L. Inorganic nitric compounds as nitrates and nitrides have not been detected. The sanitary and chemical tests prove the water to be naturally pure. The low fluoride concentration defines the water as drinkable and acceptable for all age groups of customers. The water is hydrocarbonic-sodium-calcium-magnesium; hydroarmonic-chloridic and sulphatic-sodium magnesium.

Healing Indicators

These mineral waters can be used in the treatment of: respiratory system diseases as well as cardiovascular and nervous system functional disorders; blood circulation diseases, second rate allergies; locomotory malfunctions, gynecological disorders, etc.

Healing and prophylactic centers are developed in Varna city and Pomorie town, and in "St. Constantine and Elena," Riviera and Albena resorts. Seawater and climatic procedures as well as balneo-therapeutic treatment is offered in these centers making use of outdoor and indoor mineral water and sea water pools, thermal water baths, lye treatment, manual therapy, herbal treatment, etc.

Thermal Water Application

Up-to-date geothermal stations that operate all year have been built in the north Black Sea region after 1980. They provide space heating, air conditioning and ventilation, domestic hot water for hotels and spa centers. The geothermal stations are located in Varna city (2.5 MWt and 3.5 MWt), Chaika resort (2.0 MWt), "St Constantine and Elena" resort (15 MWt) and "Golden sands" resort (0.35 MWt).

CONCLUSIONS

The wide variety and the high quality of pure thermal waters in Bulgaria combined with the extremely favorable natural and climatic conditions, a good spa base

plus mineral water healing traditions justify a long-term investment policy for the development and improvement of the existing resorts.

In parallel to that, there are conditions favoring small local centers in the spirit of today's tendencies in the so called "countryside tourism" and traditional healing as well as to widely use the renewable energy sources in our every day life.

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REFERENCES

- Bojadgieva, K.; Shterev, K.; Hristov, H. and M. Balabanov, 1999. "Complex Utilization of Geothermal Waters in the Town of Sapareva Banja (SW Bulgaria), High Priority National Project," World Solar Programme 1996-2005, Bulgaria.
- Karakolev, D., 1984. "Basis of Balneology. Medicine and Sports, S" (in Bulgarian).
- Karakolev, D., 1994. "Bulgaria-Country of Mineral Springs, S" (in Bulgarian).
- Petrov, P., Editor, et al., 1998. "Reassessment of Hydrogeothermal Resources in Bulgaria. 1998." Report for the Ministry of Environment and Waters, National Geofund, Sofia, Bulgaria. (in Bulgarian).
- Vladeva, L. and D. Kostadinov, 1996. "Bulgarian Potable Mineral Waters, I part, S" (in German).