Physicochemical Characteristics and Usage Possibilities of Elbasan Thermal Water

Elvin Çomo, Edlira Tako, Albana Hasimi, Rrapo Ormeni, Olger Gjuzi, Mirela Ndrita

Abstract**—**In Albania, only low-enthalpy geothermal springs and wells are known, the temperatures of some of them are almost at the upper limits of low enthalpy, reaching over 60 °C. These resources can be used to improve the country's energy balance, as well as for profitable economic purposes. The region of Elbasan has the greatest geothermal energy potential in Albania. This basin is one of the most known and most used thermal springs in our country. This area is a surface with a number of sources, located in the form of a chain, in the sector between Llixha and Hidraj and constitutes a thermo-mineral basin with stable discharge and high temperature. The sources of Elbasan Springs, with the current average flow of thermo mineral water of 12-18 l/s and its temperature 55-65 °C, have specific reserves of 39.6 GJ/m^2 and potential power to install 2760 kW potential power. For the assessment of physicochemical parameters and heavy metals, water samples were taken at 5 monitoring stations throughout 2022. The levels of basic parameters were analyzed using ISO, EU and APHA standard methods. This study presents the current state of the physicochemical parameters of this thermal basin, the evaluation of these parameters for curative activities and for industrial processes, as well as the integrated utilization of geothermal energy. Thermomineral waters can be utilized for heating homes in the surrounding area or further, depending on the flow from the source or geothermal well. There is awareness among Albanian investors, medical researchers, and the community about the high economic and therapeutic efficiency of the integrated use of geothermal energy in the region and the development of the tourism sector. An analysis of the negative environmental impact from the use of thermal water is also provided.

Keywords**—**Geothermal energy, Llixha, physicochemical parameters, thermal water.

I. Introduction

ALBANIA has a significant geothermal energy potential. The springs of geothermal waters that come to the surface extend almost throughout the Albanian territory from the north to the southeast. Geothermal fields containing geothermal waters have a temperature greater than 45 °C. Only low enthalpy geothermal springs and wells are known in Albania. The springs of Elbasan are well-known and used sources since the Roman period. The springs of Elbasani contain hot sulphureous waters, which are created at a depth of about 13,000 meters from the earth's surface, at high pressure and temperatures, as a result of the union of oxygen with hydrogen and other chemical substances. Pushed by the high pressure of the gases, they come to the surface through cracks in the rocks. The springs of Elbasan are among the most popular in the country. This is because it is one of the only centers that has used the thermal waters near it for decades, where health tourism is developing in a real way. The first and quite complete study of the thermal mineral waters of Albania was carried out in 1956-1957 by Avgustinski et al. [1]. This study included the largest part of the country's thermal mineral resources as well as many deep drillings for the research of oil and gas that have given thermomineral springs. The greatest asset of this study is the chemical analyzes of the waters, which include determinations of macrocomponents, many microcomponents, as well as free and dissolved gases. The formation of resources is related to three important links, which are: water-bearing structures, underground water supply, and their drainage routes. The aquifer structure of the sources of the Elbasan springs is a carbonate anticline structure and is represented by the Cretaceous and Paleocene carbonate formations that are placed at depth, which are carstified and have high permeability; they are covered by Oligocene and Miocene silty and mollasic formations with very low permeability. Analyzes and geological-structural and hydrogeological characteristics of the Elbasan Springs area indicate an intermountain artesian basin that is characteristic of wrinkled areas. The characteristics of thermal waters vary depending on the composition of minerals and the temperature reached [3]. One of the most comprehensive classifications of thermal and mineral waters for health purposes is presented as [1]:

- Based on temperature;
  - < 20 °C cold waters
  - 20-35 °C warm waters
  - 35-42 °C hot water
  - > 42 °C very hot waters.
- Based on dry waste;
  - < 1.0 g/l waters with weak salinity
  - – 5.0 g/l waters with low salinity
  - 5.0 – 15.0 g/l waters with average salinity
  - 15.0 – 35.0 g/l waters with high salinity
  - > 35.0 g/l brine.
- Based on the content of carbon dioxide dissolved in water;
  - 0.5-1.4 g/l weak carbonated waters
  - 1.4-2.5 g/l carbonated water with medium concentration
  - > 2.5 g/l of strong carbonated waters (waters that "gas"

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carbon dioxide freely).

- Based on the total hydrogen sulphide gas content (ΣH2S);
- – 10.0-50.0 mg/l weak sulphide waters
- – 50.0-100.0 mg/l hydrogen sulphide waters with medium concentration
- – 100.0-250.0 mg/l strong sulphide waters
- – > 250.0 mg/l very strong hydrogen sulphide waters.

A. The Thermal Mineral Springs of Llixha and Hidrajt in Elbasan

The sources of thermal mineral waters of Llixha come out about 12 km south of the city of Elbasan [8]-[10]. They drain along the Prifti stream at a distance of about 2 km from the Elbasan-Gramsh Road. Near the springs of Llixha, along the valley of the stream, the village of Llixha is located. The center of Tregan Municipality is also located here. During the last few years many centers have been set up for curative purposes.

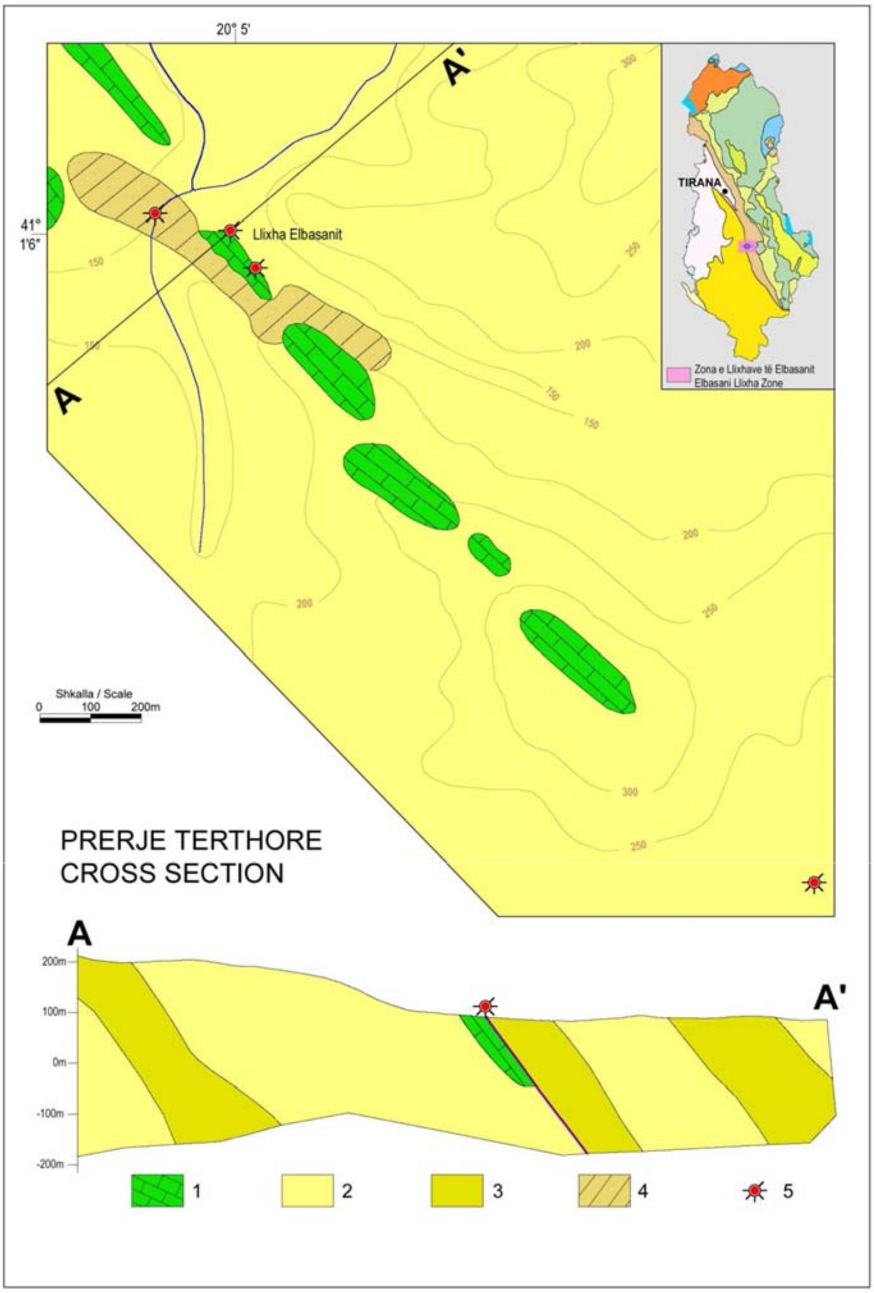

Fig. 1 Geomorphological Map of Llixha Elbasan [2]: 1-Calcolistolith; 2-Clay; 3-Conglomerate; 4-Caolinized rock; 5-Thermal springs

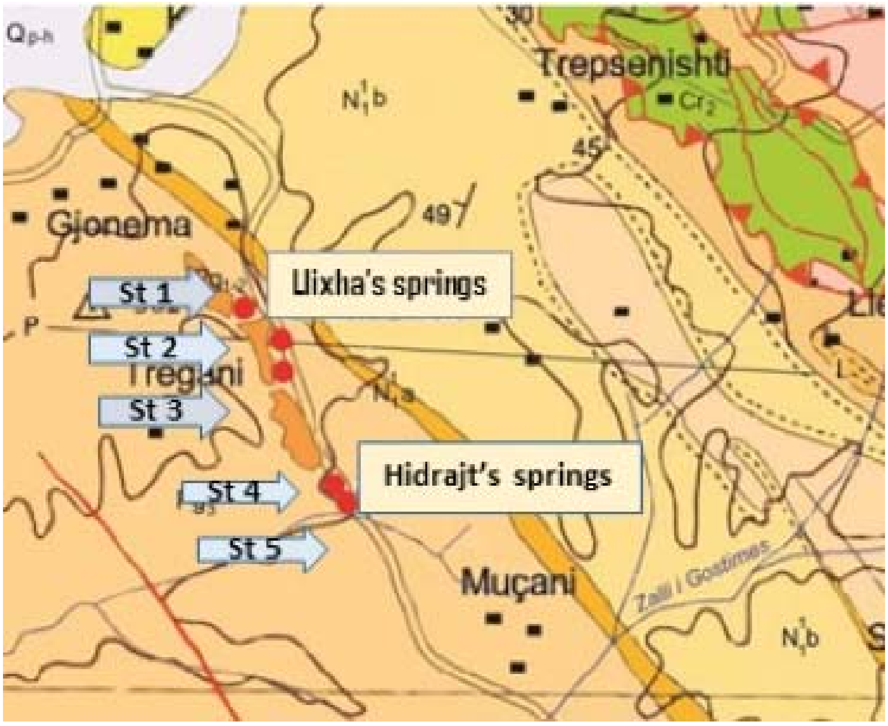

Fig. 2 Hydrogeological section and monitoring stations

The springs of Hidrajt's thermo-mineral waters come out about 13-14 km south of the city of Elbasan. They are located about 1.5 km southeast of the springs of Llixha on both sides of the Banja stream valley, about 2 km east of the Elbasan-Gramsh highway. The area of Elbasan springs is built by flychoidal formations of the Oligocene as well as mollasic formations of the Miocene (Fig. 1) [2]. The border between these formations runs parallel to the source line and east of them at a distance of less than 100 m in some places.

B. Climatic Conditions and Hydrography of the Area

The area, in which the springs are located according to the climate division of Albania, is mainly set in the Central Hilly Mediterranean region. The main characteristic of the climate of these areas is dry summer and wet winter. The air temperature regime, the geographical position, the different relief forms are significantly reflected in the climatic conditions of the area and especially in the air temperature values. The climate of the Llixha area is Mediterranean, hilly and warm. The average annual temperature is 15 ºC, while that of January is 6.5-6.8 ºC, while that of July is 24 ºC. The minimum temperature has reached -10 ºC, while the maximum temperature has reached 42 ºC. The average annual rainfall is 1165 mm [12]. The greatest amount of precipitation falls in the winter season. The hydrography of the area around the geothermal springs is made up of several streams, the most prominent being the Kusha and Zaranika streams. Both of these streams are powerful, as they carry large amounts of water. Specifically, the Kusha stream is connected to the source area, not because it passes by the thermo-mineral source, but because it cuts between the carbonate anticline of Letan, which is the largest water supplier and storage of the hydrothermal basin.

II. Procedure and Experimental Methods

A. Monitoring Protocol

The study was carried out in the period of 2022 in the area of Llixha and Hidraj Elbasan and 5 monitoring stations, representative of the area, were selected for monitoring. The monitoring stations are shown in Table I: Kozan (St 1), Tregan Para Hotel Ylli (St 2), Tregan Hotel Ylli (St 3), Tregan Nosi (St 4), Hidraj Çekrezi (St 5).

TABLE I
Coordinates of the Main Sources of the Elbasan Region

St	Geothermal stream	N	E	H (m)	Discharge m^3/s
St 1	Kozani	N 41°07'35"	E 20°0'59.7"	173	24.3
St 2	Tregan 1	N 41°01'59.3"	E 20°04'18.7"	154	5.18
St 3	Tregan 2	N 41°01'58.9"	E 20°04'13.6"	150	6.18
St 4	Tregan 3	N 41°01'22.7"	E 20°05'7.77"	163	6.0
St 5	Hidrajt	N 41°1'13.7"	E 20°05'15.8"	257	3.0

The sampling procedure was carried out according standard sampling methods described in "Standard Methods for the Examination of water and wastewater" APHA [4].

For the samples taken, plastic containers made of polyethylene with a quantity of 1 liter were used according to the type of parameter that would be analyzed in the laboratory. Metal samples were taken in 1.5 lt plastic bottles and acidification was done with HNO_3 [6].

B. Experimental Procedures

"The testing of water - Merck", 1998 and ISO standard 5667-2: 1991 are used for experimental procedures. In detail the parameters: water temperature, pH, electrical conductivity, TDS, were measured directly in the field using the multiparametric probe. Heavy metals were determined by the method of Atomic Absorption Spectrometry (AAS), with graphite furnace atomization.

III. RESULTS AND DISCUSSION

A. Physicochemical Parameters

Temperature is a physical parameter for which measurements are carried out in the field (sampling point). Fig. 3 shows the temperature trend at the five monitoring stations. The water temperature decreases from the first station where it is 64.7 °C to the fifth station with a value of 56.6 °C.

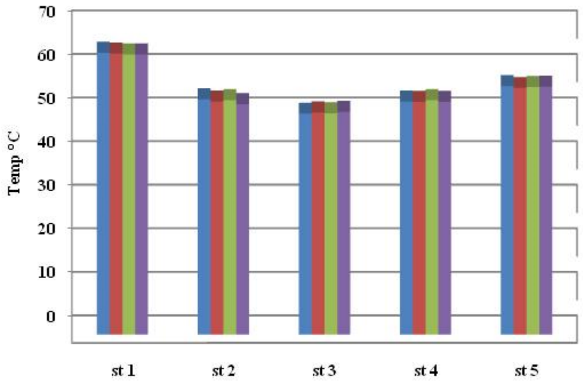

Fig. 3 Variation of temperatures (■ first monitoring series, ■ second monitoring series, ■ third monitoring series, ■ fourth monitoring series)

Fig. 4 shows the progress of conductivity in the five stations. This parameter shows an increase from St 1 to St 5 and a slight fluctuation between the monitoring series. We find the smallest values of this parameter in station St 1 (from 11.44 to 12.6 mS/cm). The increase is almost the same in all measurement locations where the values fluctuate from 12.5 to 17.2 mS/cm.

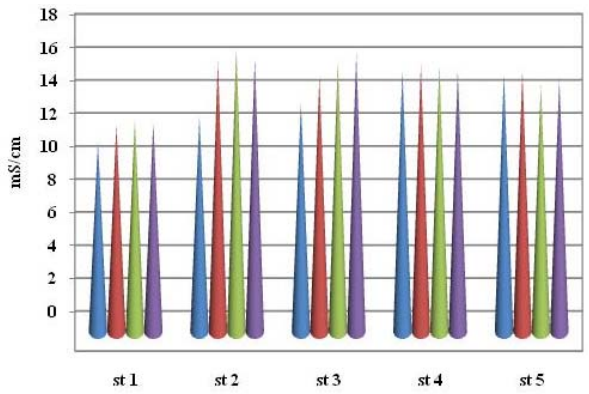

Fig. 4 Variation of conductivity (■ first monitoring series, ■ second monitoring series, ■ third monitoring series, ■ fourth monitoring series)

pH is one of the main indicators of water quality. Fig. 5 shows the data obtained from the study. As can be seen, the values of this parameter fluctuate from 6.34 to 6.75. The values of this parameter have a fluctuation both from station to station, but also between the received series.

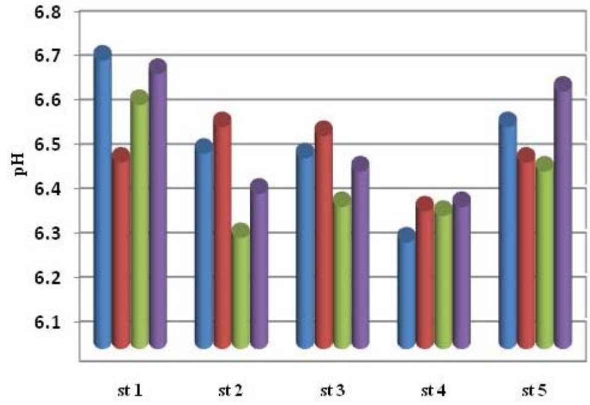

Fig. 5 Variation of pH (■ first monitoring series, ■ second monitoring series, ■ third monitoring series, ■ fourth monitoring series)

B. Nutrients

The concentration of ammonium nitrogen is a good indicator of water pollution and the intensity of mineralization processes of organic matter in sediment and water. The estimation of ammonia fluxes from sediment rocks to the near-bottom water allows conclusions to be drawn on the intensity of biogeochemical processes at the water-sediment interface [5]-[7], [11], [14].

The values of this parameter show a fluctuation both within and between series. The lowest value of 3.95 mg/l was observed at station 1, while the highest value of 23.0 g/l was observed at St 3, as shown in Fig. 6.

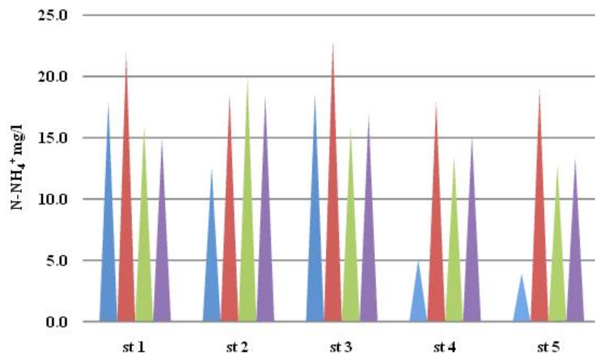

Fig. 6 Variation of ammonium nitrogen (■ first monitoring series, ■ second monitoring series, ■ third monitoring series, ■ fourth monitoring series)

Although metallic sulphides in reduced form are extensively dispersed in both igneous and sedimentary rocks, sulfur is not a significant component of the earth's outer crust. Some igneous-rock minerals of the fieldspathoidal group include sulfate, although the most prevalent and significant occurrences are in evaporite deposits. They range from 100.5 mg/l in St 1 to 188.2 mg/l in St 5. These waters show that they have a relatively high number of sulphides. The content of sulphides is presented in Fig. 7.

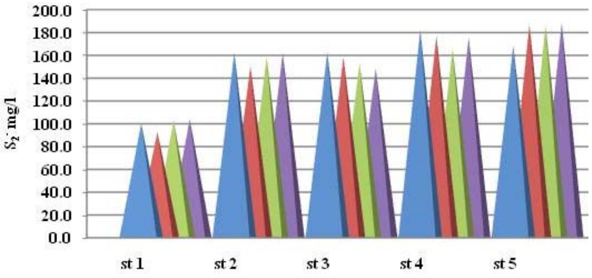

Fig. 7 Variation of sulphides (■ first monitoring series, ■ second monitoring series, ■ third monitoring series, ■ fourth monitoring series)

The element fluorine is the lightest member of the halogen group of elements and almost all tied up in rock minerals. The fluoride content is presented in Fig. 8. The measured fluoride values range from 2.12 mg/l in St 1, to 4.39 mg/l in St 5. The measured fluoride values range from 2.12 mg/l in St 1, to 4.39 mg/l in St 5.

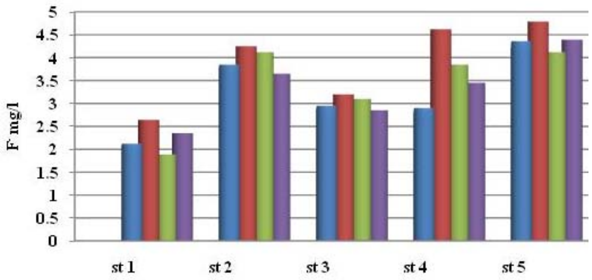

Fig. 8 Variation of fluorides (■ first monitoring series, ■ second monitoring series, ■ third monitoring series, ■ fourth monitoring series)

C. Pollution (Heavy Metals)

High lead content was recorded at all stations throughout the monitoring series. Regarding the amount of copper, there was a slight fluctuation from station to station, while for the amounts of nickel and chromium, a more pronounced fluctuation is observed from station to station. The values of heavy metals are presented in Fig. 9.

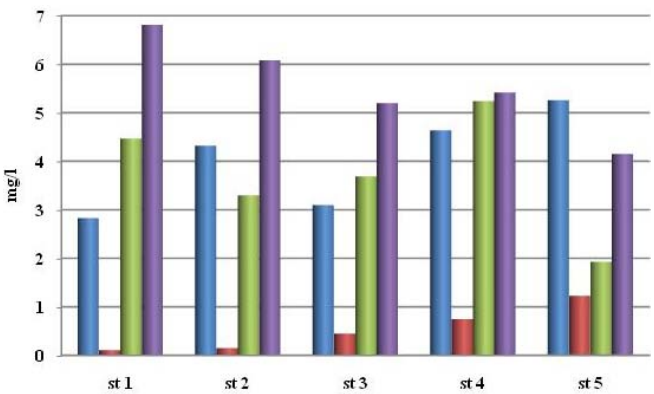

Fig. 9 Average values of heavy metals (■ Cr, ■ Cu, ■ Ni ■ Pb)

IV. Conclusion

The temperature of the main thermomineral springs fluctuates from 50 to 65 °C, which classifies them as "very hot". Water has a "slightly acidic" or "neutral" reaction, the pH fluctuates around 6.34 to 6.75. The sources of the springs of Elbasan are classified as having “medium salinity”, which remains dry in most of the springs and fluctuates at around 6.5 g/l. The prevailing value of the total content of hydrogen sulfide gas and sulfides fluctuates around 150 to 300 mg/l. According to the content of this indicator, the thermal mineral waters of springs can be classified as "hard sulphides". The fluoride content is relatively low; it fluctuates from 2.12 to 4.39 mg/l. Even the content of iodine and bromine in the sources of the Springs of Elbasan is low; usually they do not exceed 1-3 mg/l. Heavy metal values range from 0.11 to 6.81 mg/l. The temperature of these layers is determined by the density of the thermal flux, the relief of the area, its geographical position, the lithological composition of the deposits. Heating of villages, tourist hotels and their swimming pools, clinics, heating of greenhouses for the production of flowers and vegetables are among the important directions of using the energy of geothermal waters in this cascade, which should be implemented by all balneological centers existing in our country. It is estimated that these waters have specific reserves of 39.6 GJ/m^2 and potential power to install 2760 kW [9]-[11], [13]. The use of these waters polluted with chemical elements and various salts for irrigation also leads to the contamination and enrichment of the agricultural land with various salts, especially with sodium salts, sulfates and carbonates. It is therefore imperative that these waters are purified before they are sent to the drainage system and into streams and rivers, or re-injected underground into geothermal reservoirs.

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