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Suitability for tourism of Târgu Ocna and Cacica resorts and the salt mines on their territory

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Abstract: This study analyses the bioclimate of Cacica and Târgu Ocna resorts and of the salt mines on their territory, based on the Thermo-Hygrometric Index (THI). The bioclimate was analyzed based on hourly data (air temperature and relative humidity) from 2020-2022. The annual and diurnal regime of THI in the two resorts and the two underground salt mines were investigated and periods of bioclimatic comfort were identified. Thus, at Cacica, the comfort period covers the months of June-July-August and partly September, while at Târgu Ocna the period starts one month earlier (in May) and extends by one month compared to Cacica resort (until September). It is worth noting the presence of clusters of days or hours with thermal discomfort caused by heat, especially in Târgu Ocna (in July and August). Over the course of a day, bioclimatic comfort based on the THI index is reached in Cacica, during the summer, from 6.00 a.m. and lasts until midnight. In the transition months, April, May and October, comfort is felt between 11.00 a.m and 6.00. p.m. In Târgu Ocna the bioclimatic comfort is specific to summer throughout the day, with a more pronounced discontinuity in the afternoon hours, when the discomfort caused by the heat sets in. The salt mines benefit from a thermal stability that is reflected in the slightly variable THI values and in a slight cooling discomfort. The stable atmosphere and the microclimatic uniformity give Cacica and Trotuș salt mines certain balneoclimatic qualities recommended both for tourists and patients (with respiratory diseases).

1. Introduction

Climate is an essential element in the process of choosing a tourist destination and planning trips (de Freitas, 2003; Hamilton, 2005; Scott, 2010). Weather elements such as temperature, precipitation and wind are key factors in shaping the tourism experience, directly influencing the range and quality of outdoor activities. These weather variables not only determine travelers' preferences and behavior, but also influence the availability and attractiveness of tourist destinations in different seasons and geographical regions. Thus, weather fluctuations become a key consideration when planning and carrying out outdoor tourism activities, with a significant impact on traveler satisfaction and comfort (Zaninović and Matzarakis 2007, 2009; Mihăilă and Bistricean, 2018; Roșu et al., 2021, 2022).

A variety of climatic and bioclimatic indices have been developed to assess and characterize the climatic and bioclimatic conditions of a region or locality. These indices are designed to synthesize information on temperature, relative humidity and other relevant meteorological variables, thus providing a comprehensive overview of the climatic and bioclimatic potential of the resorts studied. This approach allows researchers and travelers to better understand the climatic and bioclimatic characteristics of the destination, to identify the most climatically favorable periods for visiting that region and

to optimize travel planning according to specific preferences and objectives. The use of these climatic and bioclimatic indices is a useful tool in the assessment and sustainable management of tourism, helping to promote more enjoyable and safer tourism experiences (Zaninović and Matzarakis 2007; Mihăilă and Bistricean, 2018).

The richer the natural heritage, the more attractive a tourist resort is. One such natural element is the salt mine. Throughout time, salt mines have been recognized for their therapeutic properties, and in this context, salt therapy is an effective method that has attracted the attention of the medical community since ancient times and was officially recognized more than half a century ago (Karakoca et al., 1995; Horowitz, 2010; Călin et al., 2012). Salinotherapy is effective in the treatment of respiratory diseases, with an extensive and effective practice in Central and Eastern Europe, as well as in other regions. This therapy was officially recognized in the 1950s and 1960s in Germany and Poland, marking the beginning of a significant evolution in the field of complementary medicine (Skulimowski, 1965). Research on saline therapy has been extended in Germany (Spannagel, 1961), Poland (Skulimowski, 1965), Romania (Munteanu et al., 2010; Goldan et al., 2010; Chonka, 2012), Belarus (Levcenko, 2012), Uzbekistan (Nurov, 2010), Russia (Semiletova and Kardashov, 2024).

In recent years, saline therapy is often practiced in Europe (Sandri, 1998; Chonka, 1998; Dluholucký and Rajcanova, 1998; Beamon et al., 2001, 2003; Simionca et al., 2006; apud by Simionca, 2011) in salt mines and karst caves with different parameters: Wieliczka, Poland; Solotvino, Ukraine; Bad Bleiberg, Austria; Klutert Hohl, Germany; Zlate Hory and Cisarska cave, Czech Republic; Bystrianska Jaskyna, Slovakia; Tapolca Seehohle, Hungary (Simionca et al., 2006, 2009).

These mines and caves provide favorable conditions for the treatment of respiratory diseases (Munteanu et al., 2012). In Romania, salt therapy has been implemented in several salt therapy centers, such as Salina Unirea in Slănic Prahova, Salina Turda, Cacica, Târgu Ocna, Praid and others. These centers have become important destinations for the treatment and rehabilitation of patients with respiratory diseases, and the results of bioclimatic studies and evaluations of environmental parameters in these mines have confirmed their therapeutic potential (Munteanu et al., 2012; Stănciulescu and Molnar, 2017).

The presence of salt mines near Cacica and Tg. Ocna resorts completes the rich and diversified natural offer of these resorts: the temperate climate, the indifferent sedative bioclimate, the mineral springs, the hilly relief covered with a consistent forest vegetation, the clean and aeroionized air (Mihăilă et al., 2023). In addition, saline therapy has gained popularity in these salt mines in recent years, attracting more and more tourists eager to experience its beneficial effects (in 2023, 197.158 visitors were registered in Trotuș Mine and 100.000 in Cacica Salt Mine, according to the data of Salrom).

The aim of this study is to analyze and evaluate the bioclimatic potential for tourism of the resorts of Târgu Ocna and Cacica and the salt mines located in these localities on the basis of the values of temperature, relative humidity and THI index. Proposed objectives: i) to identify during an average year, the favorable / unfavorable and comfortable/uncomfortable periods for tourism based on air temperature, relative humidity and THI index in the resorts of Cacica, Târgu Ocna and in the underground salt mines of these resorts; ii) to identify the favorable / unfavorable and comfortable / uncomfortable periods for tourism during an average day of the year or during different months of the year, based on air temperature, relative humidity and THI index in Cacica and Târgu Ocna resorts and in the underground salt mines of these resorts.

2. Materials and Methods

2.1. Study area

Cacica (4,313 inhabitants in 2023) is a balnear and climatotherapeutic destination of local interest, located in Suceava county, in the Solca-Cacica depression, at the

contact between Obcina Mare and Suceava Plateau. At an average altitude of 425 meters, the place is surrounded by hills covered by forests, with altitudes ranging from 800 meters (to the west) to 500-600 meters (to the east). Cacica has a moderate temperate continental climate. The history and development of Cacica are closely linked to the exploitation of the salt from its subsoil. Although it has a modest accommodation capacity (of 296 places), Cacica has attracted a significant number of visitors, recording 13.277 arrivals with accommodation in 2022 (NIS – National Institute of Statistics), accessed December 2023).

Cacica Salt Mine – is located in the village of Cacica (Figure 1), a site with a rich history of salt mining dating back to 1791. The entrance to the mine is 425 m above sea level, and the tourist facilities are notable for several attractions: the Salt Museum - houses a varied collection of tools, maps, photographs and various minerals, offering an insight into the archaeological culture related to salt mining; Roman Catholic Chapel of St. Varbara - located at a depth of 29 meters, this chapel is the first of its kind in a salt mine in Romania and dates back to 1806; the Orthodox Chapel (-35 m), impresses with sculpted bas-reliefs in the salt rock, illustrating religious themes; The Salted Lake- is an artificial lake dug by hand by miners at a depth of 42 m; the Dance Hall at a depth of 45 m offers a unique setting for events and recreational activities; the Dwarfs' Cave, the Sports and Leisure Hall located at a depth of 75 m offers a specific experience inside the salt mine.

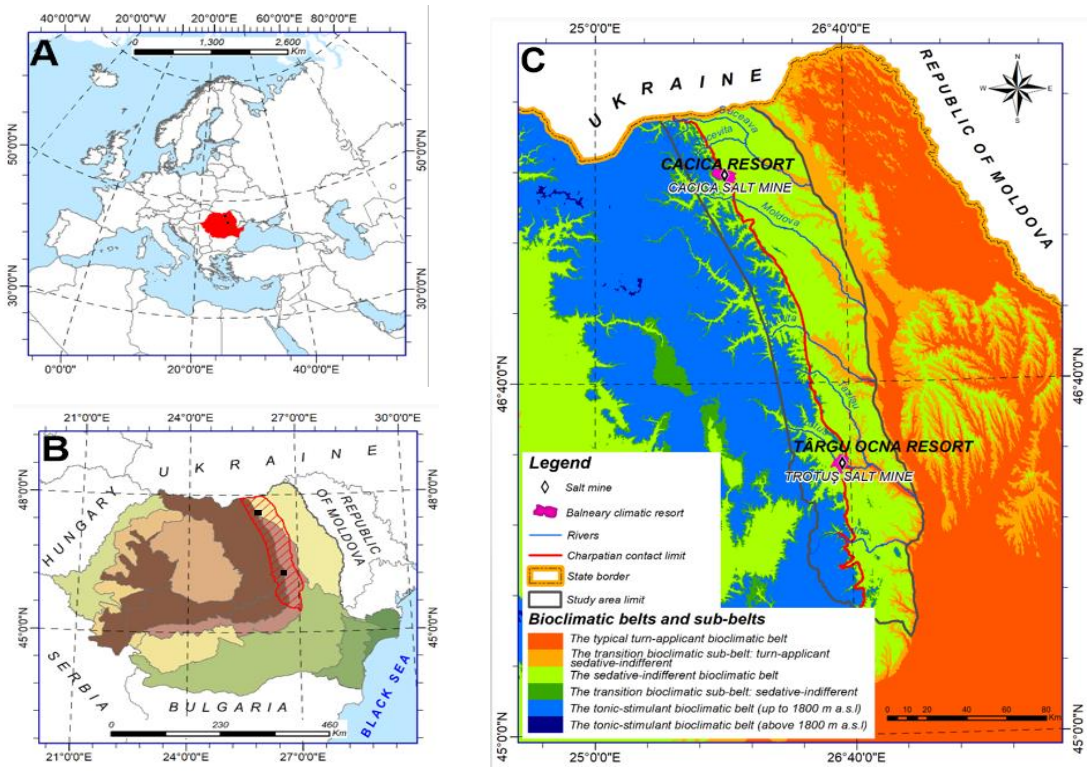


Figure 1. Geographical location of the places where aeroionometric measurements were made in the tourist resorts of Cacica, Târgu Ocna, Cacica salt mine and Trotuș salt mine (on the map of Europe and Romania - A; in the contact area Carpathians - Suceava Plateau, Subcarpathians of Moldavia - B, at the contact between the sedative indifferent and tonic stimulating bioclimatic levels – C)

Târgu Ocna resort (12.194 inhabitants, 2023), classified as being of national interest, is distinguished by the presence of the salt mine (Trotuș Mine) and by the benefits generated by therapeutic saline aerosols. Located in the Cașin Depression, at the confluence of the Trotuș and Slănic rivers, it is at an average altitude of 263 meters and has a moderate temperate continental climate (Figure 1). Târgu Ocna resort attracts tourists interested in balneotherapy and health care, recording 14.593 arrivals in 2022

(NIS, accessed December 2023). The town has seven mineral water springs (sulphurous, chlorinated, sodic, weakly bicarbonate, hypotonic), which are used for therapeutic purposes to treat digestive tract, hepato-biliary, chronic gynecological, rheumatic and respiratory tract diseases.

Trotuș Salt Mine, located in Târgu Ocna resort (Figure 1), is the third largest salt mine in Romania and one of the oldest in the country. With the largest treatment base in Romania, covering 13.000 square meters, located in the Trotuș Mine at a depth of 240 meters, it offers ideal conditions for relaxation, sports activities and treatment for respiratory ailments. The salt mine has sports fields, a place of worship (St. Varvara Chapel), a salt museum, a performance hall and an exhibition of salt works. Tourist services have been diversified with the creation of the recreational base in the Târgu Ocna mine branch, since 2010. A number of tourist facilities are located in the salt mine: a saltwater pool, showers, medical office, terrace and shop.

2.2. Methods and means

For precision measurements of air temperature and relative humidity at the 2m level we used the Data Logger CEM DT-171 sensors. The altitude of the entrance to the Cacica salt mine is 427 m above sea level, and that of the Trotuș salt mine from Tg. Ocna is located at 285 m. The depth at which the temperature-humidity sensors were placed was -75 m, compared to the level of the entrance to the salt mine at Cacica, and -240 m compared to the level of the entrance to the Trotuș salt mine from Tg. Ocna. On the surface, the sensor from Cacica was located at 424m altitude, and the one from Tg. Ocna was located 242m above sea level. We also integrated meteorological data obtained from the meteoblue.com website to ensure proper context and a complete analysis of local climate conditions.

2.3. Data obtained and research methodology

At each observation site in the two resorts and the two salt mines we obtained 18.288 hourly values for temperature and humidity (2020-2022).

In order to determine the bioclimatic characteristics based on the THI index in Cacica and Târgu Ocna resorts, as well as in Cacica salt mine and Trotuș salt mine, a total of 4 sensors were placed at representative points. The sensors were set to record temperature and humidity hourly. The period analyzed started on 01.01.2020 at 12.30 p.m. and ended on 31.12.2022 at 23.30 p.m. Data were downloaded to the computer every 3 months, at which time the batteries in each sensor were replaced. At the end of the 3 years, a large amount of data was obtained: 73.152 air temperature and relative humidity values.

The THI or Heat Stress Index is an indicator derived from the calculation of the Thom Discomfort Index, based on air temperature and relative humidity. It is used to assess climatic conditions throughout the year (Bistricean, 2018).

Table 1. THI value scale (°C), weather type and bioclimatic comfort / discomfort type, according to Bistricean, 2018

THI Index (°C)	Types of time	Types of bioclimate
-20 <THI ≤ - 10	Excessively cold	Bioclimatic discomfort by cooling
-10 <THI ≤ - 1,8	Very cold	
-1,8 <THI ≤ +13	Cold	
+13 <THI ≤ +15	Cool	
+15 <THI ≤ +20	Comfortable	Bioclimatic comfort
+20 <THI ≤ +26,5	Warm	Bioclimatic discomfort by heating
+26.5 <THI ≤ +30	Very warm	
THI >+30	Heat	

For the THI calculation we used the calculation formula proposed by Kyle in 1992:

$$THI°C = Tusc - (0.55 - 0.0055 \cdot UR) \cdot (Tusc - 14.5)$$

where: Tusc – air temperature in °C, measured at the dry thermometer; UR – relative humidity (%).

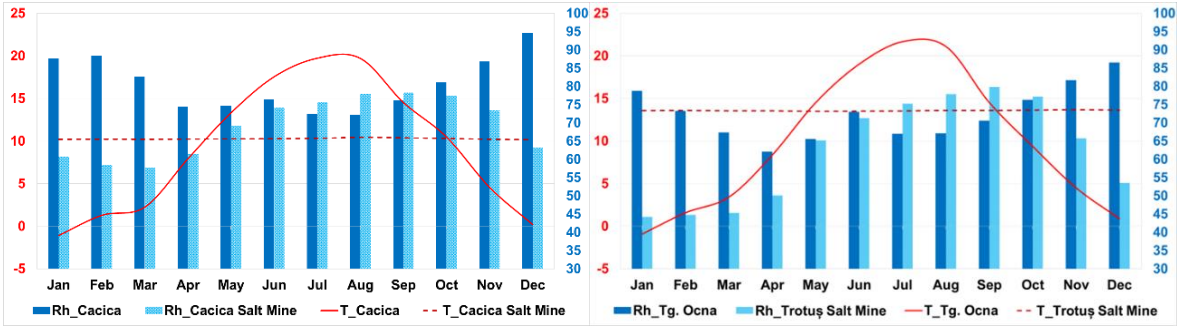
3. Results

3.1. Analysis of the annual regime of air temperature, humidity and THI based on seasonal values of these elements and indices

The annual regime of climatic elements, based on mean seasonal data, shows significant seasonal variations both between resorts and between salt mines, highlighting the diversity of microclimatic conditions. Air temperature follows a similar pattern at the surface, with lower minimum values at Cacica and higher maximum values at Târgu Ocna. Underground, the temperature remains relatively constant in each salt mine (between 10.2-10.4°C in Cacica and between 13.5-13.7°C in the Trotuș salt mine). Relative humidity reaches maximum values in winter and autumn in both resorts, while in the salt mines, maximum values are recorded in summer and autumn. The annual THI regime follows a profile similar to that of air temperature, both at the land surface and in saline subsurface environments. For resorts, THI shows bioclimatic comfort (15-20°C) in summer and bioclimatic discomfort through cooling, which is moderate in spring and autumn and more pronounced in winter. In saline subterranean environments, THI remains relatively constant and falls within the specific value limits of bioclimatic cooling discomfort corresponding to a cool weather pattern.

3.2. Analysis of the annual regime of air temperature, humidity and THI based on monthly values of these elements and indices

The monthly values of climate elements clearly reveal the distinctive features of the climate in the two resorts. Cacica, located at more northern latitudes, is distinguished by an average annual temperature of 9.2°C, with a minimum of -1.1°C in January and a maximum of 19.7°C in July and August. In contrast, at Târgu Ocna, a resort located further south, the average annual temperature is 9.8°C, with a minimum of -0.9°C in January and a maximum of 21.7°C in July. In the salt mines, air temperature variations are small, ranging between 10.2°C and 10.4°C in the Cacica salt mine and between 13.5°C and 13.7°C in the Trotuș salt mine (Figures 2a and 2b).



(a) **(b)**

Figure 2. Annual regime of air temperature and relative humidity based on monthly values of these elements in Cacica resort, Cacica salt mine – a, Târgu Ocna and Trotuș salt mine – b (2020-2022)

The air humidity shows an inverse proportional trend to the surface temperature: for Cacica resort an annual average of 80.6 % was calculated, with a maximum of 94.7 % in December, and a minimum of 72.1 % in August. For Târgu Ocna, an annual average humidity of 72.5 % was calculated, with a maximum of 86.6% in December, and a minimum of 62.1 % in April. In the salt mines, the humidity shows more significant

variations compared to the temperature: in the Trotuș mine the annual amplitude of humidity is 35 % and lower in the Cacica salt mine (annual amplitude of humidity is 20.6 %). Both in the Cacica salt mine and in the Trotuș salt mine, the humidity reaches maximum values in summer and minimum values in winter months (Figure 2a and 2b).

The monthly THI values reveal periods characterized by bioclimatic comfort and discomfort in the two resorts. Thus, cooling discomfort generally prevails from the second half of September to the first half of May, while bioclimatic comfort is a bioclimatic characteristic, from the second half of May to the first half of September. In the case of the salt mines, bioclimatic cooling discomfort is present throughout the year (Figure 2). In the Trotuș salt mine the discomfort is lower than in the Cacica salt mine, in the former the monthly average THI values are close to the lower limit of the comfort range (Figure 3).

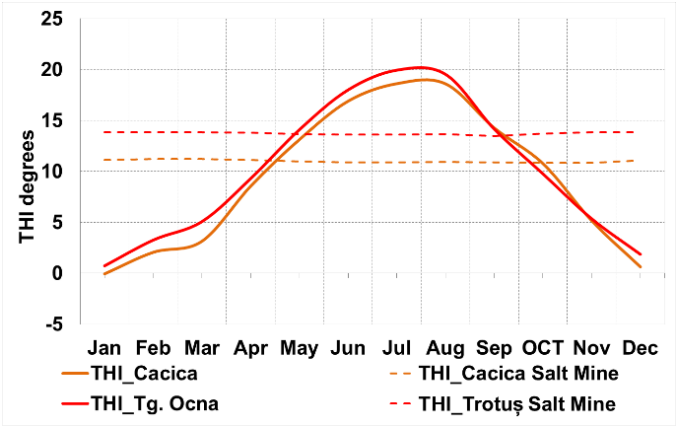
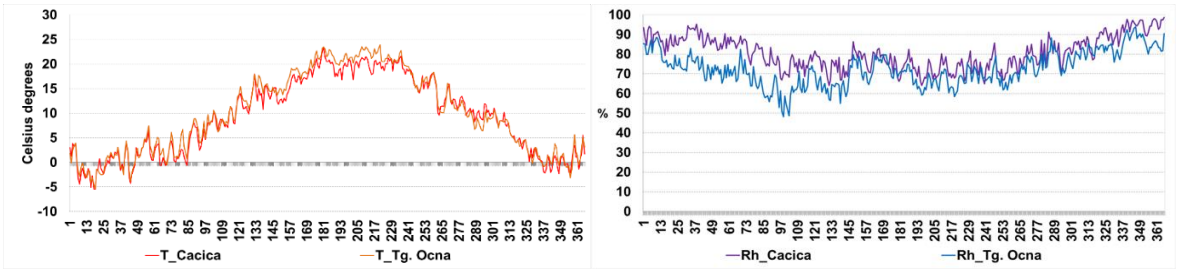


Figure 3. Annual THI regime based on monthly values in Cacica, Tg. Ocna resorts, Cacica salt mine and Trotuș salt mine (2020-2022)

3.3. Analysis of the annual regime of air temperature, humidity and THI based on the diurnal values of these elements and indices

Analysis of the annual temperature and humidity regime clearly shows the latitudinal and altitudinal differences between the two resorts. The diurnal temperature values follow a general upward trend starting in January (-5.1°C in Cacica and -4.6°C in Târgu Ocna), peaking in August (23.4°C in Cacica and 24.8°C in Târgu Ocna) and then following a general downward trend until December. Air humidity values show a more variable interdiurnal trend than air temperature, with highs recorded in December (95 % in Tg. Ocna and 100 % in Cacica) and lows in April (65 % in Cacica and 50 % in Tg. Ocna). The most significant differences in humidity between the two resorts are observed from December, they increase in the first months of the year - February-April, but they fade from May onwards (Figures 4a and 4b).



(a) **(b)**

Figure 4. The annual regime of temperature – a and relative humidity – b based on the daily values of the two elements in the resorts of Cacica and Târgu Ocna (2020-2022)

Figures 5 and 6 indicate that both resorts show similar annual regime patterns from diurnally averaged data for temperature and humidity, but there are also a number of

nuanced differences between the two localities. For example, days with temperature values above 20°C have a share of 17 % in Tg. Ocna and only 9.3 % in Cacica.

The relative humidity is generally higher in Cacica than in Tg. Ocna, especially on days during the winter months, with average values between 80 - 90 % in Cacica and between 70 - 85 % in Tg Ocna.

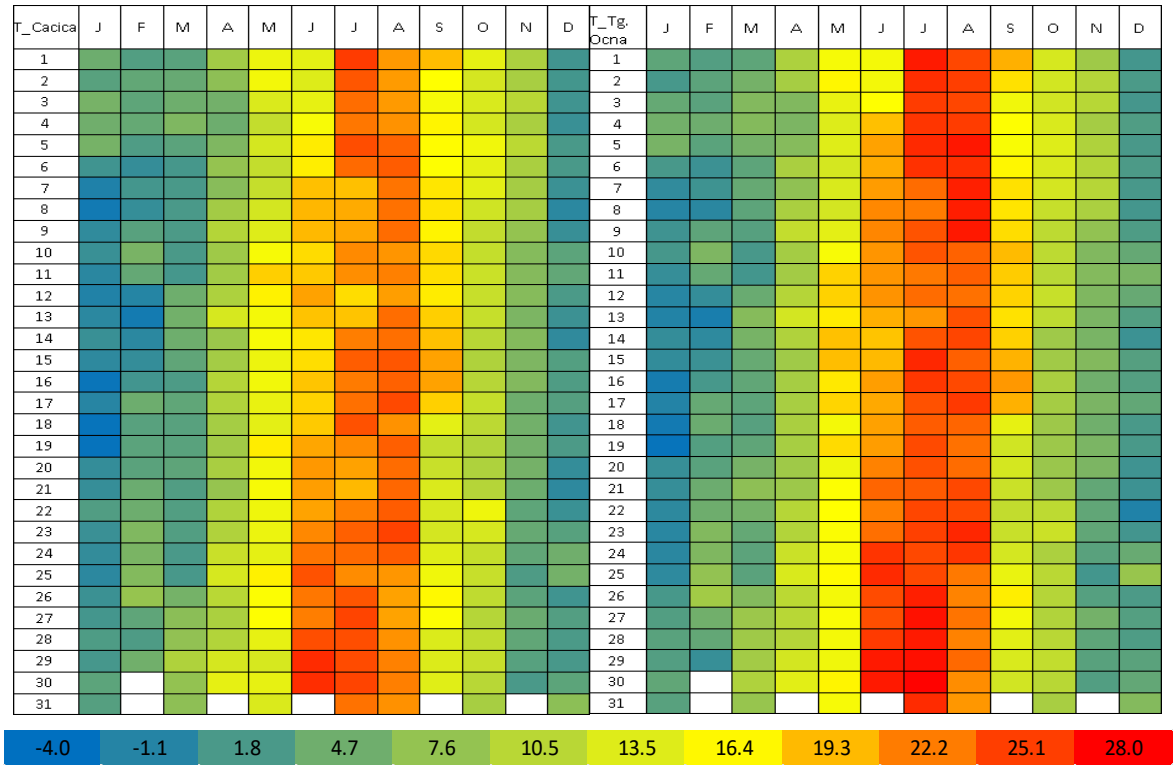


Figure 5. Interdiurnal air temperature regime in Cacica and Tg. Ocna resorts (2020-2022)

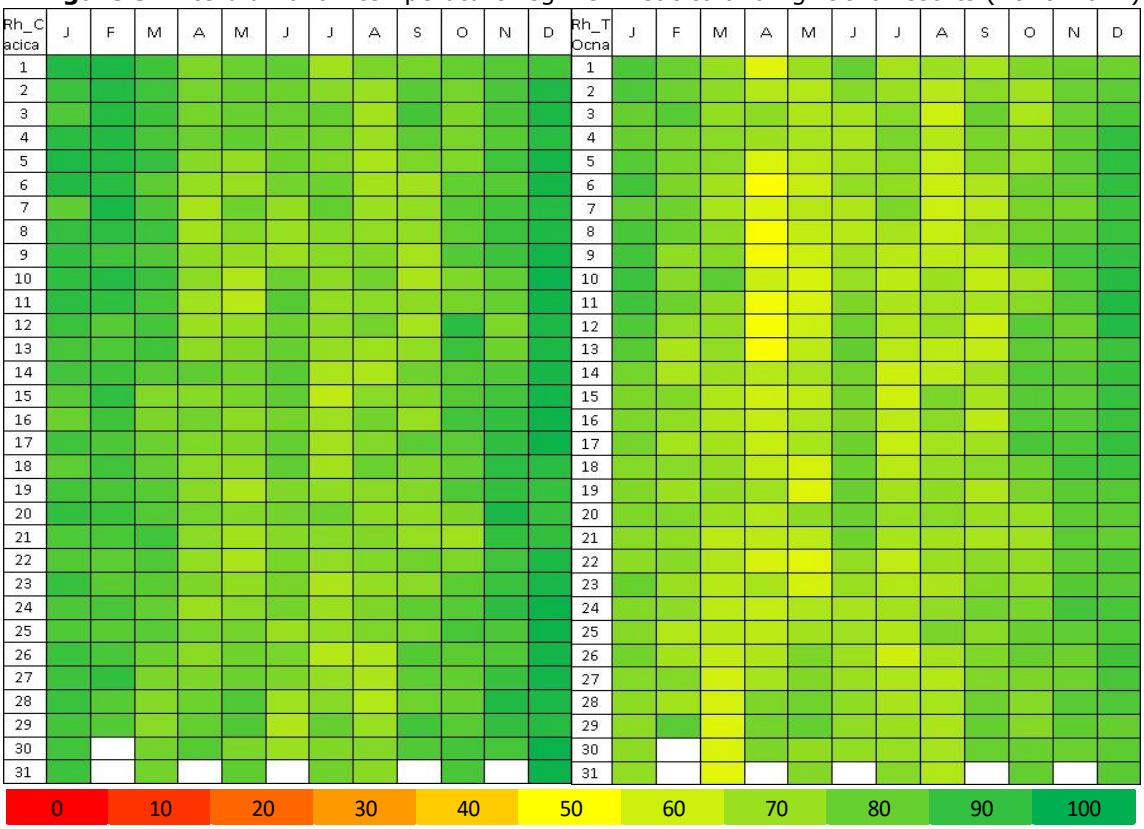
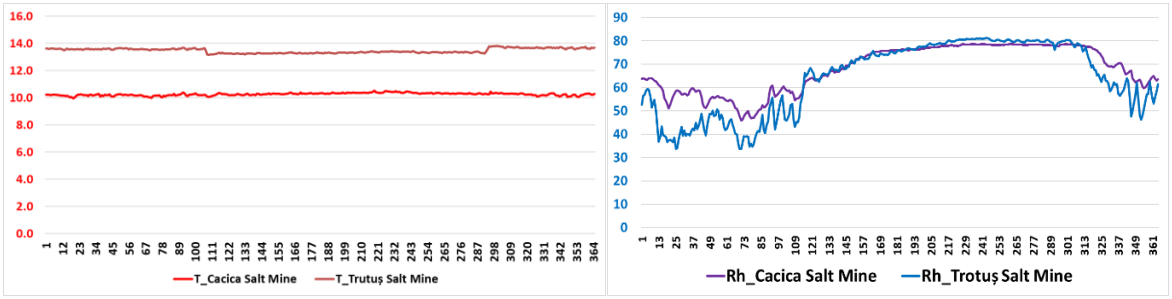


Figure 6. Interdiurnal relative humidity regime in Cacica and Tg. Ocna resorts (2020-2022)

At the salt mines, air temperature stability is observed. Interdiurnal variations in temperature are minimal: between 10.2 and 10.5°C in Cacica salt mine and between 13.2 and 13.7°C in Trotuș salt mine. The slight decrease in air temperature during the summer in the Tg. Ocna salt mine is related to the ventilation system of this salt mine with a remarkable depth. Relative humidity shows higher interdiurnal variations in the cold season (on the background of large variations in air pressure), but reduces its interdiurnal variability during the warm season in both resorts (Figures 7a and 7b). The large and relatively constant number of tourists (who breathe and sweat), the lower interdiurnal pressure variations, the more active internal dynamics of the air that brings into suspension more saline aerosols, but also their hygroscopic properties, make the humidity remain constant at higher diurnal levels compared to cold season days. The average relative humidity was 68.1 % in Cacica salt mine and 64 % in Trotuș salt mine.



(a) **(b)**

Figure 7. Annual regime of temperature -a and relative humidity - b based on diurnal values in Cacica and Mina Trotuș salt mines (2020-2022)

THI remains constant in salt mines along the year, with index values corresponding to bioclimatic cooling discomfort. In Cacica salt mine, THI varied between 10.8 and 11.3°C, and in Trotuș salt mine THI ranged between 13.4 and 13.9°C (Figure 8).

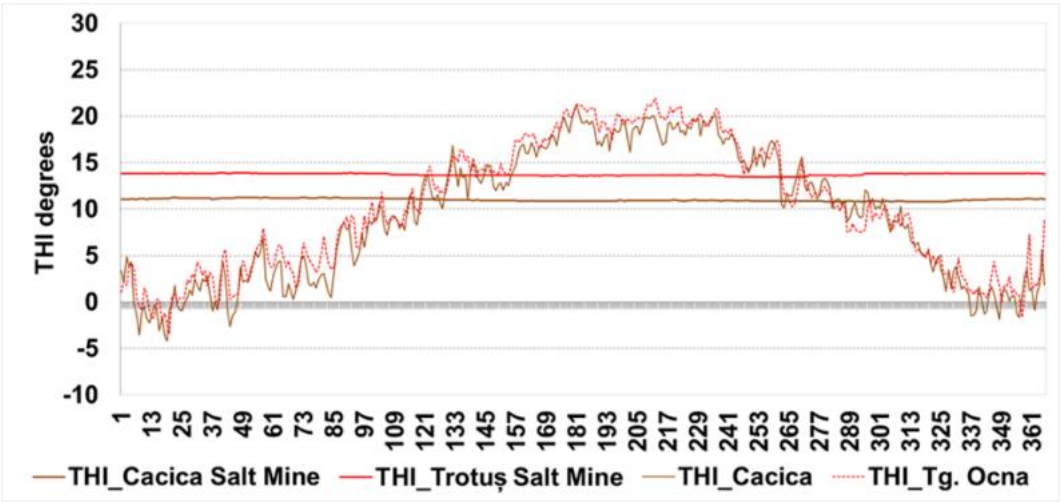
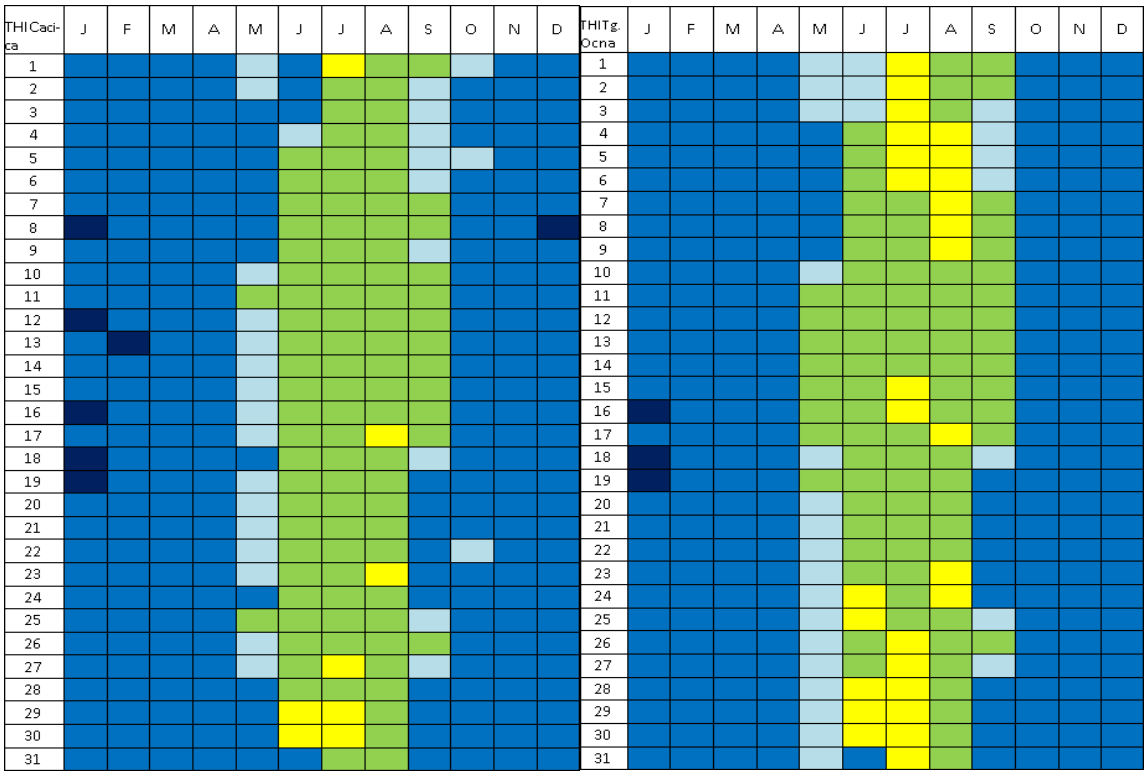


Figure 8. Annual THI regime based on diurnal values in Cacica, Tg. Ocna resorts and in Cacica and Trotuș salt mine (2020-2022)

At the level of the two resorts, THI falls into 3 distinct bioclimatic comfort / discomfort classes, as shown in Figures 10 and 11. Throughout the year, THI varies from negative values on days of winter months (-2 - 3°C) to values exceeding 20°C on days of summer months (Figure 8 and Figure 9).

Bioclimatic comfort is obvious in June, July, August and partly in September / May, with a higher time share in Cacica (25 % compared to 22.3 % in Tg Ocna). The discomfort caused by heating is more pronounced in Tg Ocna, representing 7.5 % of the total time, while in Cacica it is only 2.1 %.



THI Index (°C)	Types of bioclimate
-10 <THI ≤ - 1,8	Bioclimatic discomfort by cooling
-1,8 <THI ≤ +13	
+13 <THI ≤ +15	
+15 <THI ≤ +20	Bioclimatic comfort
+20 <THI ≤ +26,5	Bioclimatic discomfort by heating

Figure 9. The annual THI regime based on diurnal values in Cacica and Tg. Ocna resorts (2020-2022)

3.4. Analysis of the diurnal regime of air temperature, humidity and THI based on hourly values

The isopleth air temperature representations (Figure 10) allow us to easily analyse the temperature values for each hour of the day, for each month of the year and for each individual resort. So-called diurnal/annual heat islands are easy to spot by all tourists, many of whom have no in-depth meteorological or biometeorological training. Thus, in the winter months (January-February), the temperature reaches its lowest values during the night (between -3.4°C and -2.0°C), followed by a gradual increase until midday (between 2.5°C and 6.2°). In the summer months (June-August), the temperature records the highest values during the afternoon (between 25.1 and 27.2°C), followed by a gradual decrease during the night until the morning (between 15.7°C and 20.5°C).

Representations of air humidity in the two resorts allow to identify the hourly and monthly variation of this meteorological element, as well as to identify the periods of the year characterized by higher or lower humidity. In both stations, humidity reaches maximum values in the winter months and during the night, while minimum values are recorded from the spring months, especially in summer and until late autumn. Lowest values are reached between morning (6:30 am- 7:30 am) and afternoon (between 2:30 pm and 3:30 pm). It is noticeable that the diurnal and annual period of low humidity is more "compact", easier to outline in the case of Cacica and more "spread out", more diffused in time, in the case of Tg. Ocna (Figure 11). June is a month of slight interruption

of the diurnal and annual "island" of lower humidity and this aspect is more pronounced in the case of Trotuș salt mine.

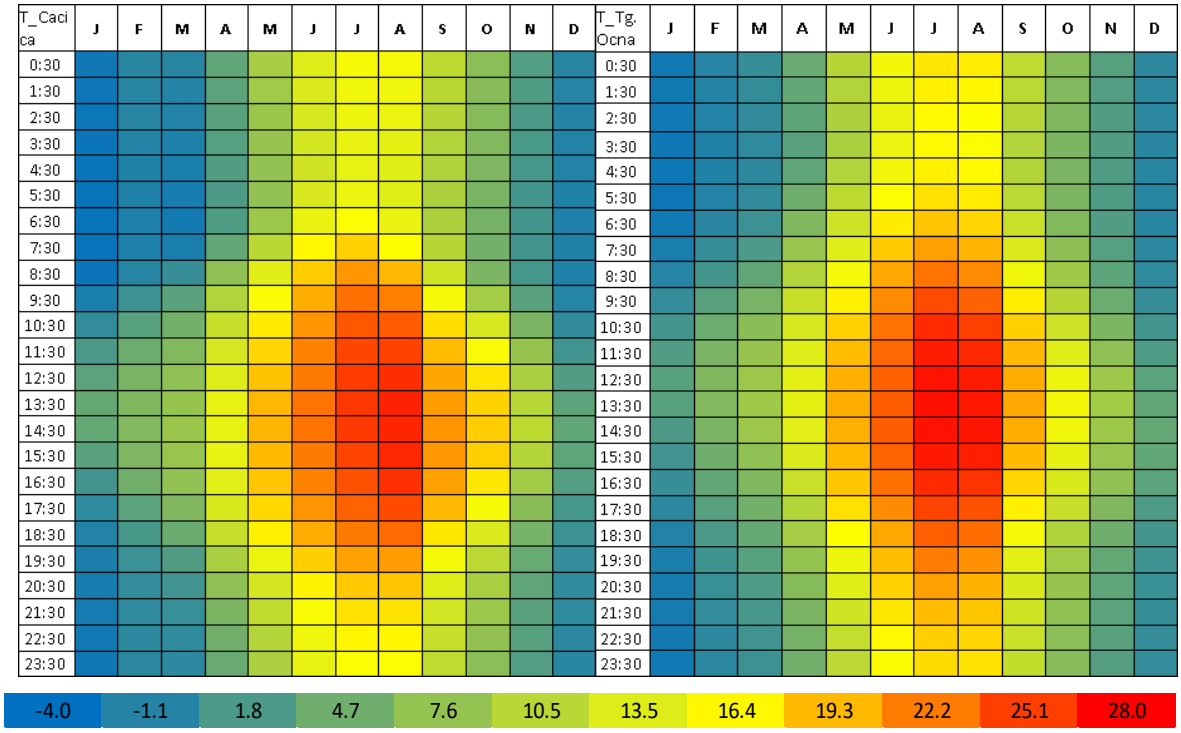


Figure 10. The average hourly air temperature values for each month of the year in Cacica and Tg. Ocna (2020-2022)

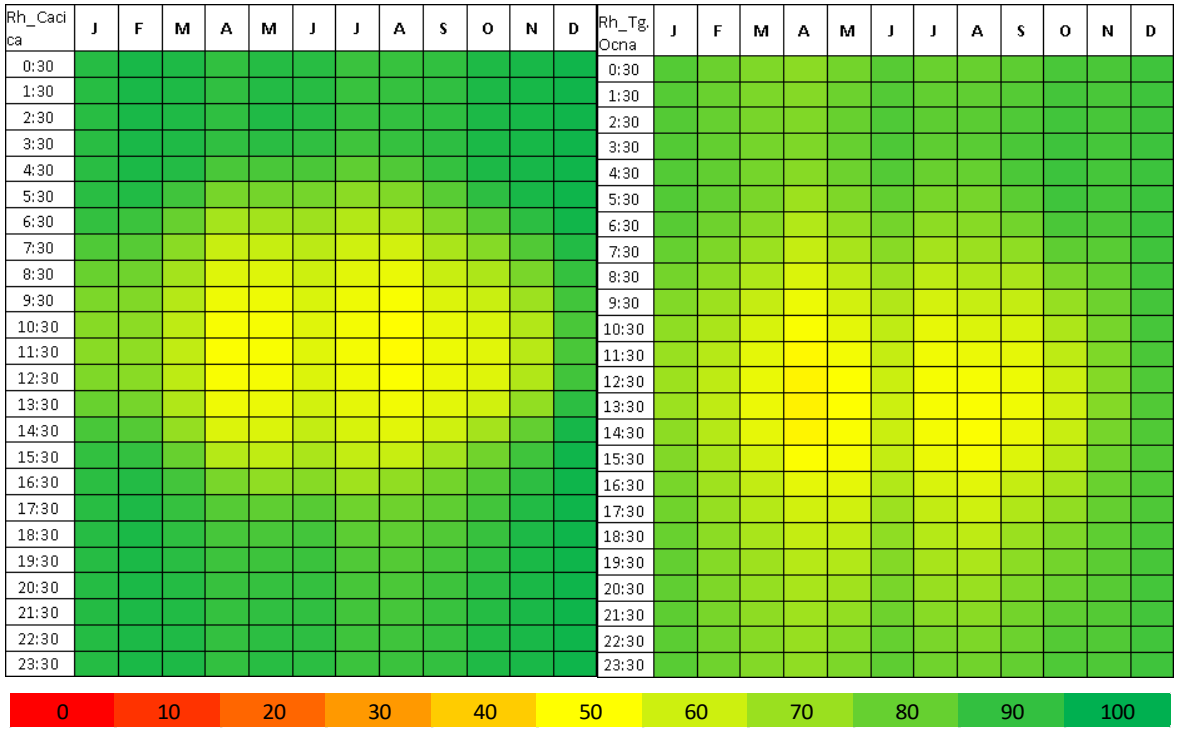


Figure 11. The average hourly values for each month of the year of the relative humidity in Cacica and Tg. Ocna (2020-2022)

Representations of relative humidity in salt mines (Figure 12) highlights for the warm season, the role of the specific ventilation processes of the two underground cavities, but also of the presence of a much larger number of tourists who change the hygric balance in their air.

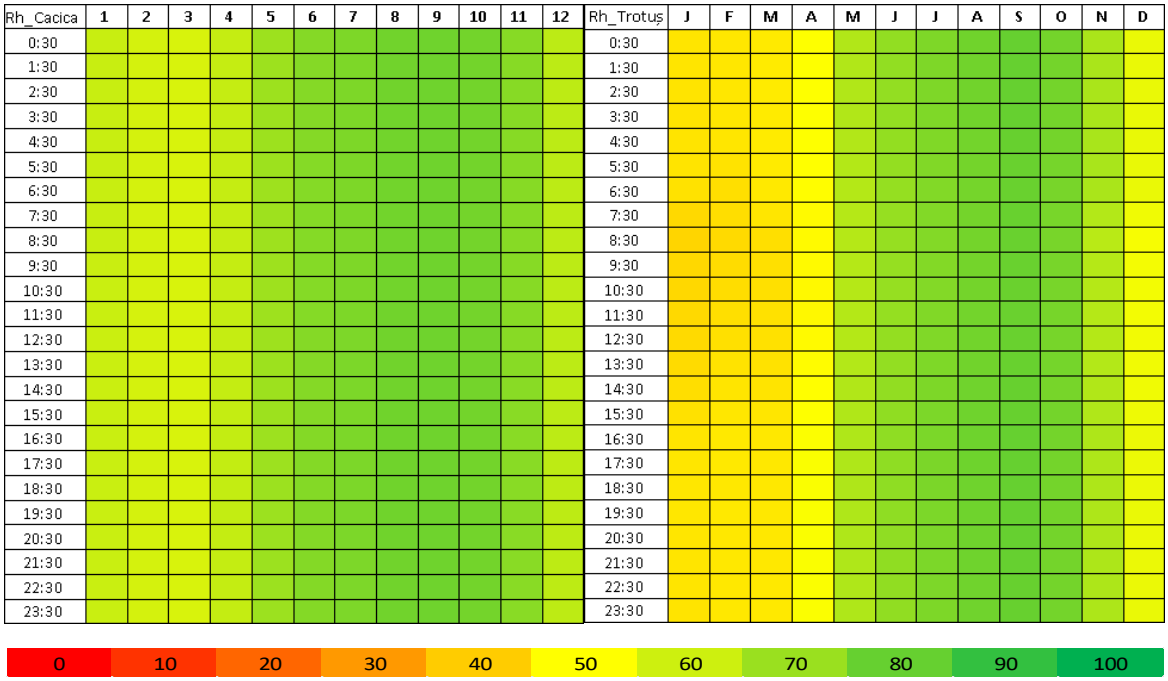


Figure 12. The average hourly values for each month of the year of the relative humidity in the Cacica and Trotuș salt mines (2020-2022)

In salt mines, in the winter and spring months, the air is warmer and imposes a low relative humidity. As the warm season enters, the air temperature in the salt mines remains cooler than the temperature outside, and the relative humidity inside the salt mines increases, as the thermal contrasts between inside and outside increase, peaking in July-August. The differences in humidity between the two salt mines are also due to the types of ventilation: mechanical in the case of Trotuș salt mine (between 04:00 am and 12:00 am, between 15 March and 15 October, and between 04:00 am and 8:00 pm, between 16 October and 14 March) and natural ventilation through wells in the Cacica salt mine. The large number of visitors contributes to these differences, which in the case of the Trotuș salt mine reaches 2000 tourists/day in the summer months. Under these conditions, the relative humidity in the Trotuș salt mine varies more (between 41 and 80 %) and less (between 57 and 78 %) in the Cacica salt mine.

Analysis of the diurnal regime of hourly averages of air temperature and humidity (Figures 13 and 14) allows the identification of significant daytime variations and differences between the two resorts and between the two salt mines, providing a detailed insight into the local climate and microclimatic conditions.

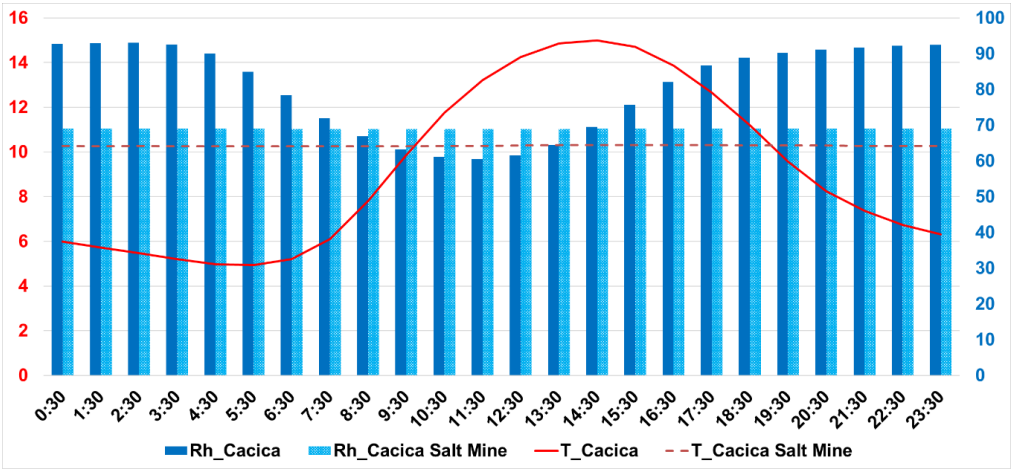


Figure 13. Diurnal regime of hourly averages of temperature and relative humidity in Cacica resort and salt mine (2020-2022)

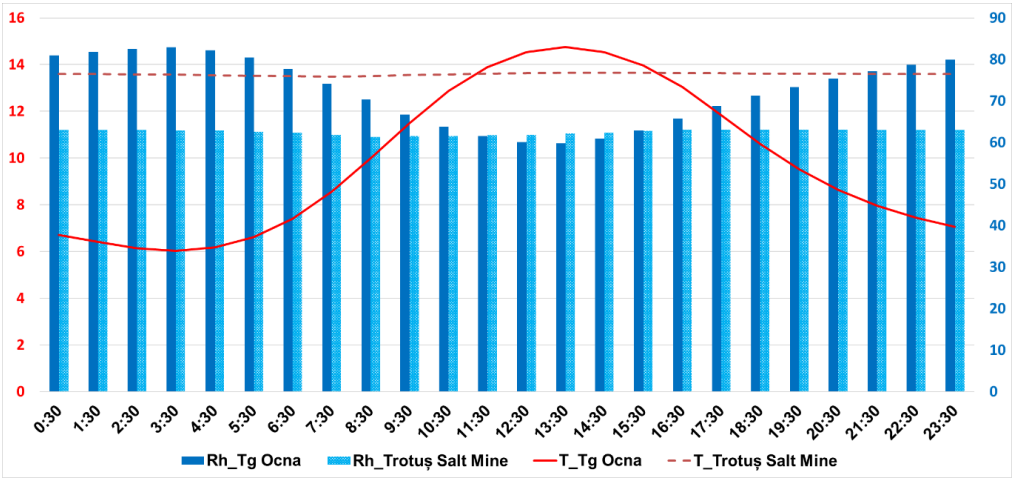
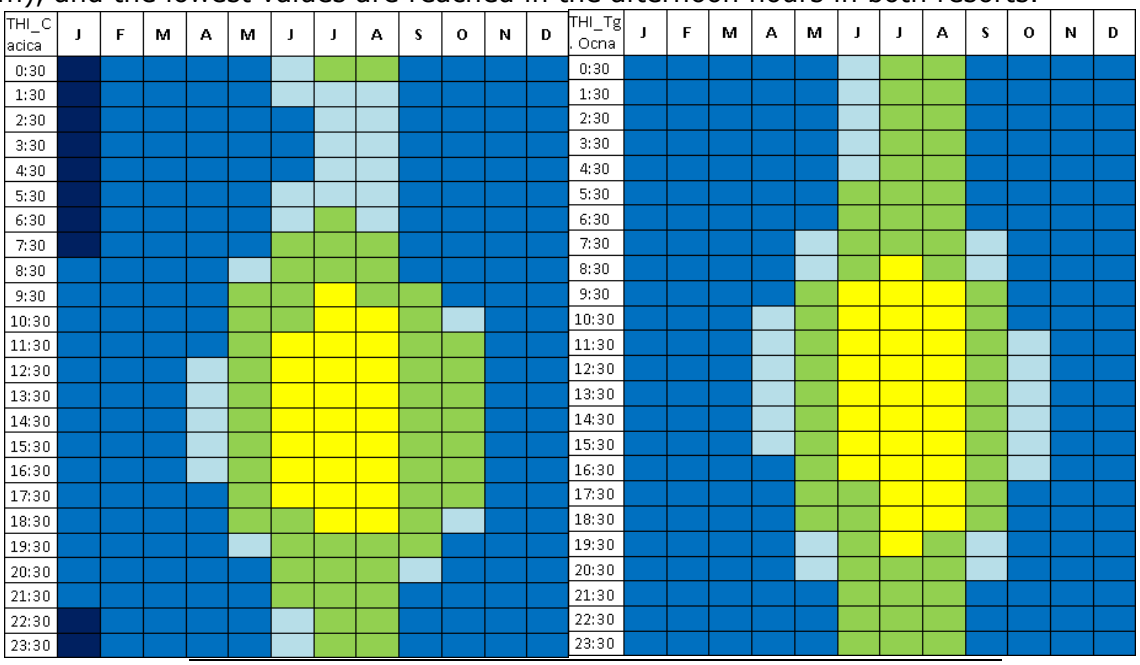


Figure 14. The diurnal regime of hourly averages of temperature and relative humidity in Tg. Ocna resort and Trotuș salt mine (2020-2022)

We note that on an average day of the year, the air temperature in Tg. Ocna varies between 6.1°C and 14.8°C, while in the Trotuș salt mine it stabilizes between 13.5°C and 13.7°C. In Cacica resort, the temperature oscillates between 4.9 and 15°C, while in the Cacica salt mine, it remains almost constant (about 10.3°C). In general, the lowest temperature values are recorded in the early morning (between 4:30 am and 6:30 am), and the highest in the afternoon (between 12:30 am and 3:30 pm). The relative humidity on an average day of the year is between 60 and 93 % in Cacica, and between 68 and 69 % in the homonymous salt mine. At Tg. Ocna the relative humidity varies between 60 and 82 %, and in the Trotuș salt mine, it varies very little (between 61 and 63 %). The highest values of relative humidity correspond to the night hours (10:00 pm - 04:00 am), and the lowest values are reached in the afternoon hours in both resorts.



THI Index (°C)	Types of bioclimate
-10 <THI ≤ - 1,8	Bioclimatic discomfort by cooling
-1,8 <THI ≤ +13	
+13 <THI ≤ +15	
+15 <THI ≤ +20	Bioclimatic comfort
+20 <THI ≤ +26,5	Bioclimatic discomfort by heating

Figure 15. The average hourly THI values for each month of the year in the tourist resorts Cacica and Tg. Ocna (2020-2022)

Figure 15 gives us a clear picture of the THI for each hour of the day and each month of the year corresponding to the two resorts. The two "islands" with thermal discomfort through heat in the summer months stand out, in the time interval 9:30 am -6:30 pm in Cacica and 8:30 am -7:30 pm in Tg. Ocna. The period with bioclimatic comfort is longer in Tg. Ocna (from May to September for the whole time slot) and shorter in Cacica (from May to October, but with interruptions in the time slot 1:30 am - 5:30 am). Bioclimatic discomfort through cooling dominates temporally in the two resorts and is more pronounced in Cacica during the night/morning hours in January.

In the air of the salt mines, THI is almost constant both during the hours of the day and throughout the 12 months of the year. In Cacica salt mine, THI maintained between 10.8 and 11.2°C, and in Trotuș salt mine, THI varied between 13.4 and 13.9°C. Under these conditions, the air in the salt environment imposes, as dominant, a bioclimatic discomfort by cooling, which is more pronounced in Cacica salt mine.

4. Discussion

Our study presents a series of limitations induced by the means used. The sensors used recorded only air temperature and relative humidity. With these two elements we were able to determine only one representative bioclimatic index: THI. We can also calculate the temperature-humidity index (ITU) which is an index of thermal and hygric discomfort due to heating, but its values would not be representative for the microclimate of the salt mines. The use of wind sensors (which are somewhat more expensive) would also allow the calculation of other bioclimatic indices. But, in the context of the reduced dynamics of the air in the salt mines, the results that would be obtained in terms of microbioclimate would not differ much from the current ones, but would confer a plus related to the more precise measurement of the endogenous bioclimatic comfort / discomfort.

Previous studies carried out in Cacica and Tg. Ocna resorts, as well as in the related salt mines, have been approached by Romanian researchers from various tourist, climatic and bioclimatic perspectives. These researches confirmed our results, and they are highlighted in the literature.

Cacica and Târgu Ocna resorts have been in the attention of Berlescu (1982), Teleki et al., (1984), Teodoreanu and Gaceu (2013), Silișteanu et al. (2020), in studies carried out on the scale of the whole Romania, in the analysis part of the salinotherapeutic potential. In these studies, the authors did not elaborate much on the thermal, hygric and bioclimatic peculiarities of the two salt mines and did not make such detailed comparisons with the surface microclimate of the two resorts as found in our study.

For example, the studies conducted by Simionca (2011) and Călin et al. (2011) in the Romanian salt mines indicated average values of the air temperature in the Cacica salt mine between 10.2 and 10.5°C, and of the humidity of 76 %. The two collectives of authors noted the cooling discomfort imposed by the microclimate in the salt mine, emphasizing at the same time its tonicity, the salinotherapeutic and balneoclimatic potential of this salt mine. Antonovici (Munteanu) et al., (2023) obtain values of temperature and air humidity identical to those of our study in the Trotuș salt mine. However, our study, through the longer duration of the observations and the temporal resolution taken to the hourly level, gives the certainty that we managed to establish the defining thermo-hygric features of the air in the two salt mines, features corroborated with those of the surface microclimates. Enache (1974, 2016) highlighted, on one hand the stability of the measured parameters (temperature, humidity, air pressure) in the salt mines and, on the other hand that the bioclimate of the salt mines presents a certain degree of discomfort through cooling.

Our results regarding the THI agree for the surface observations with those obtained by Bistricean (2018) at the level of the entire Moldova region or applied to Cacica and Tg. Ocna. Also, Mihăilă et al. (2019) reported similar values to ours for average surface and underground temperature and relative humidity in both Cacica resort and the

homonymous salt mine. In addition, Roșu et al. (2022) identified the periods of bioclimatic favorability in the summer months in the area between Sucevița and Tg. Ocna. Our results complement and strengthen the previous ones regarding the bioclimatic characteristics of the two resorts.

5. Conclusions

Cacica and Tg. Ocna have a valuable balneoclimatic potential: mineral springs, nearby salt mines, indifferent sedative bioclimate, ozonated and aeroionized air and rich forest vegetation. To detail the bioclimatic characteristics, we analysed temperature, relative humidity and the bioclimatic index THI.

In this study, we identified favorable / unfavorable and comfortable / uncomfortable bioclimatic periods for tourism along the year. Thus, the most favorable periods for tourism activities correspond to the summer months, followed by spring and autumn, when the values of the climatic elements analysed and the THI (15-20°C) correspond to bioclimatic comfort, and outdoor tourism activities can be carried out without restrictions.

We have also argued through calculations and concrete values, which are the periods / hours during an average day of the year with favorable / unfavorable periods and bioclimatic comfort / discomfort for tourism. From this point of view, we can state that in the summer months, the period with bioclimatic comfort starts in the morning (6:30 am) and continues until late evening (11:30 pm). It should be noted that, starting with the summer months, 10:30 am marks, in both resorts, a period of slight bioclimatic discomfort through heating that lasts until 6:30 pm in Cacica and 7:30 pm in Tg. Ocna.

The salt mines benefit from a thermal stability, a hygric variability more relevant for the December-May interval, which is also reflected in the constant THI values (10.2 - 10.4°C in Cacica salt mine, respectively 13.5 - 13.7°C), corresponding to a slight cooling discomfort. The stable atmosphere and microclimatic uniformity give Cacica and Trotuș salt mines certain balneoclimatic qualities, recommended both for tourists and patients with respiratory diseases.

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