THE CONSEQUENCES OF SUBSIDENCE ON THE CULTURAL HERITAGE AND TOURISM OF TUZLA

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Abstract: Tuzla was mainly characterized by two things: salt and coal. These two ore, which were abundant in this area, are responsible for the economic, social and cultural development of the city. The image of the industrial city of Tuzla starts to lose during and after the war. The vision of the new development of the Tuzla economy, apart from private entrepreneurship, is also based on investment in tourism and sustainable development. The negative, but in a certain way, and the positive influence on the development of these categories has the settlement of the city itself which was created as a result of the exploitation of salt. The paper deals with the importance of the mining industry, its consequences and the exploitation of new possibilities.

Keywords: salt mine, exploitation, subsidence, cultural objects, heritage, tourism

Introduction

Tuzla, occupies the central position of the area of northeast Bosnia and represents the economic, scientific, cultural and health centre of this region (Figure 1). All settlements of Tuzla, starting from Neolithic times and further, were tied to rich salt deposits. In Tuzla, the oldest lake dwellings settlement in Europe was found, dating from Neolithic (young stone age), as well as a large number of items from that time, and especially the vessels for salt production. It should be noted that the Neolithic settlement was found in the very centre of today's city of Tuzla. The names of the settlement were always labelled as salt: Soli, Salines, Memlehaizir, Tuz, Tuzla. (4)

![Figure 1 Tuzla](image)

The first document on the exploitation of salt springs dates back to 1548. The salt is produced throughout the year and saline wells were in the Salt Square
(Liberation Square today). The first schools in the city are open from 1826, the first hospital in 1874, and the first pharmacy opened 6 years ago. The establishment of the Austro-Hungarian authorities started an intensive development of industrial production, primarily salt and coal, and the construction of a modern city infrastructure. Underground mining of salt that took place several decades, has caused a numerous subsidence that in some parts of the city reached 12 meters. (13) The trail of the missing sea and past times is testified by Salt Square and the Archaeological Park with a prehistoric lake dwellings settlement. (14)

Before the war Tuzla was mainly defined by salt and coal. These two ore, which were abundant in this area, are responsible for the economic, social and cultural development of the city. The image of the industrial city of Tuzla starts to lose during and after the war. The vision of the new development of the Tuzla economy, apart from private entrepreneurship, is also based on investment in tourism and imagination about sustainable development (Figure 2).

![Figure 2 Tuzla today](image)

**Salt mines in Tuzla**

Tuzla is unique city by its natural riches in the matter of 650 million tons of salt rocks under the surface of the city. These rocks together with saltwater are part of Pannonia Sea that in the past backed out to the Black Sea. The oldest written source about the salt boiling in the area of today’s Bosnia and Herzegovina has been found in written sources of Greek writers Pseudo Aristotle and Strabon. (Bakalović at al.: 1)

Organized production and sale of salt comes with the digging of a well in the present Salt Square in 1476. On the Salt Square there were up to 80 pans in which the salt water from a salt well was cooked. Salt has been connecting different countries, cultures and civilizations of that time. The Tuzla salt was one of the basic items that the Bosnian eyalet presented at the International Economic Exhibition in Philadelphia 1876. (4)

In 1884 salt pipeline was built which connected salt factory in Simin Han with two salt wells in Gornja Tuzla. The salt factory started to work in 1885.
Unfortunately, the object of salt factory in Simin Han was demolished down after its closing. The opening of the salt factory in Kreka 1891 preceded researches about existence of the salt on the hill Trnovac (Figure 3).

Figure 3 Salt factory in Kreka (19th century)

By stopping of the production and conservation of the machine, and for the hundred years anniversary of the opening of the first salt factory in Simin Han (1885-1985), salt factory Kreka was turned into Museum of salt which testifies about the way of salt production through all historical epochs, from Neolithic ‘til the year of 1971 (Figure 4).

Figure 4 The museum of salt, Kreka

On the Trnovac beat started the building of the salt wells for exploitation of saltwater in 1885 because of supplying of the salt factory in Kreka (Figure 5).(Bakalović at al:1)
The basic and oldest aspect of exploitation of salt from the deposit consists in the use of groundwater, which naturally feeds the deposit, dissolves easily soluble stone salt and creates a saturated saline, which is pumped to the surface through a well. In 1971, geological explorations began, and the concept was adopted, according to which the exploitation of this deposit will be carried out by controlled leaching with individual wells from the surface of the terrain. The "Tetima" rock salt deposit in the plan has an irregular elliptical shape of length about 2.2 km and a width of up to 1 km of the maximum thickness ranging up to 200 m.(5)

Shortly afterwards began sinking city, as a result of uncontrolled leaching of brine from salt rocks, on which is located the city. Sinking will reach its peak in the 70s of the last century, when the city lost several thousands of residential, commercial and cultural facilities.(4)

The mine was again put into trial work on 5 exploration wells released in March 1992, after only two months, the trial work was interrupted. After the revitalization of mining facilities, plants and devices, production was restarted at the beginning of 2001. In the period 2005-2014, 16 explorations and exploitation wells were drilled, which makes a total of 21 out of 100 wells projected. Based on the knowledge about the geological composition of the deposits and verified reserves of rock salt in the Tetima deposit, and the expressed need for salt water, the remaining exploitation life of the deposits is approximately 50 years.(5)

Subsidence

General facts about subsidence

Subsidence may occur under the influence of a number of factors: geological discontinuity and void, collapse of old works, moving caused by sliding of soil, or change the stresses in the massif, earthquakes, and other disorders in the soil and rocks. Moving the surface of the terrain in the mining works zone is a phenomenon that is associated with the excavation of the ore deposits, which disturbs the state of the natural balance in the soil. This causes displacements and deformations of the mass around the excavated area and the
overrun of the elastic deformation and collapsed, so that subsidence can reach up to the surface. The surface of the ground above the mining underground mine can sink, rush, or move horizontally, causing breaks in buildings, splitting roads or breaking the surface of the terrain. The appearance of the slip and the mechanism by which the tailings are strained and displaced depends on the physical properties of the tailings, mineral raw materials and materials of the floor, and the size of the individual excavations and the achieved digging ratio.(Nurić 2004:2)

**The characteristic parameters of ground settlement**

The zone affected by the displacement is related to the excavated space. The sizes of the vertical and horizontal displacements are changed, depending on the position of the terrain point towards the boundaries of the excavated space. Due to the difference in movement in the neighboring points, deformations occur in the vertical and horizontal plane. Many parameters affect the surface subsidence, such as depth layers of tailings, mining methods, height dug and geological characteristics of layers. Moving points on the surface of the terrain occurs after a certain time from the beginning of exploitation and achievement of certain dimensions of the excavated space. The length of the time interval between the start of the exploitation and the occurrence of the displacement of the points of the terrain surface depends primarily on: physical-mechanical characteristics of the mass in the roof, depth of excavation, the area of the excavated space, speed of progress of mining works.(Nurić 2004:2)

**Subsidence above the salt mine in Tuzla**

So far, about 90 million m$^3$ of salt water has been exhausted from the Tuzla deposit, with an average salinity of 300 kg/m$^3$, ie approximately 27 million tons of salt has been exploited, resulting in a deficit of a solid mass of about 12.6 million m$^3$. This had the consequence of a gravitational movement, ie, lowering of the roof, which results in slow processes of transferring these movements, falling down through the massif all the way to the surface of the field, where the process manifests itself in the form of its slipping, taking into account the far greater surface of the distribution relative to the primary surface of the efflux in the productive formation. The area of the well location is about 25 ha, the area of salt deposit is about 160 ha, while the surface area of the field is over 500 ha. The maximum value of the sinking on some counts and amounts to over 12 meters. Salt dissolution leads to the collapse of ceiling deposits and changes in the primary state and properties in the massif. These complex processes at the site began well before the start of artificial exploitation of brine and had characteristics of light natural processes. By artificial exploitation of
brine they were only accelerated and took on the characteristics of effective processes with visible consequences and on the surface of the terrain. This resulted in the damaging and demolition of a number of public, cultural, educational, educational, health and private buildings from the narrower zone of the city, as well as a displacement of about 10,000 residents in other parts of the city. (5)

**Facilities of importance threatened by subsidence**

**Pinga and Barok**

Few parts of the city have changed as an area around the former Pinga. An inconspicuous and completely devastated part of Tuzla, a silent witness of the city's sinking, was turned into its most attractive part by the construction of the Pannonian Lake Complex (Figure 6).

![Figure 6 Pinga](image)

After the last (1893) fire in Tuzla, an object was built that had already been named "Barok" in style and not by purpose, that name remained as long as it existed. It was made and the facade was decorated with a gypsum ornament that required a certain style-baroque and was shipped from the center of Monarchy. The building called the Barok was the most beautiful building in northeastern Bosnia and it was damaged due to a brick that was made of salty soil and water. The construction of a new Barok building was finished, modeled on an old one, but with more quality material (Figure 7). (10)

![Figure 7 Building Barok](image)
Catholic Church in Tuzla

The Roman Catholic Church in Neo-Gothic style began to build in 1893 at the ruins of the former monastery and was completed in 1896. It was built according to the Franca Mihanović project. The first reconstruction of church buildings due to subsidence was 1964. The solution turned out to be temporary, since the collapse continued. Due to the subsidence of land destroyed in 1987, at the same place, a new complex of the Catholic Cultural Center is set up, which should officially open on Christmas 2018. The conceptual solution envisages that the Catholic Cultural Center through the silhouette symbolizes the collapsed church and that the space is intended for cultural events organized by the Franciscan monastery in Tuzla together with other institutions. The facilities will be connected with an alley of Franciscans who have contributed to the cultural identity of BiH, and the opening of the center will create the conditions for starting a Department for the pipe organ in Tuzla (Figure 8).(8)

Orthodox Church in Tuzla

The Orthodox Church of the Assumption of the Most Holy Theotokos of 1874, which in the eighties of the last century was successfully saved from the sinking, since it was located in the area affected by this phenomenon (Figure 9).(15) The Orthodox Church is an indispensable symbol of Tuzla located in the central city zone, east of the city park. It was built in the period from 1874 to 1882 in the Serbian-Byzantine style. (9) In architectural terms, the church was built in neoclassical style.(12)
The Džindić mosque is located in the zone of the most intensive sinking of the terrain in Tuzla, beneath the saline wells. It is mentioned for the first time in 1701. It was renewed several times, but it always retained its original appearance. It was thoroughly reconstructed in 1863/64, as well as in 1961. This is typical mahala mosques, dimensions 7x7 m, with a wooden minaret and 16 windows. It has a square shape and it has a very decorative wooden door on two channels. The roof is quite high and covered with tiles (Figure 10). Interestingly, the upper part above the sofa rests on eight wooden pillars, which are processed in carving, which is the work of the then masters.(6)

The building is of historical, documentary and aesthetic value and is one of the most significant works of Franjo Lavrenčić, an architect who influenced the development of contemporary architecture on the ground of Bosnia and Herzegovina. In the Ottoman period, the location was between the military fort
and the Džindić Mahala. Stylish belongs to the transition between the second and third periods of contemporary architecture of Bosnia and Herzegovina. The sinking of the terrain most affected the building in the south-southeast direction, in which the direction of the buildings leaned. The largest denivelation of the northern and southern part of the building is 1.27 m. In relation to the perpendicular axis, the building moved about 5 degrees, which was why it was considered unimportant for the intended purpose. Because of the careless and innumerable, arrogant and urbicidal behaviour, the building is now in a ruinous state (Figure 11).

Figure 11 Music School building

The old municipalities

The building of the municipality was built in 1937. It houses the institution of the Tuzla municipality. The architectural style of the building is peculiar and rare, with regard to weather dating. It is a rarity monument of the artistic culture of the European modern. It was one of the few buildings that survived in the original appearance-gability state. The building was hit by the landfall, which damaged a number of significant buildings. Because of the ruinous state of the buildings, it was evicted in 2003 and was destroyed in 2015. (Figure 12).(17)

Figure 12 Old municipalities
The National Library

Initially the District Post, was put into operation in 1901. The luxurious facade of a building rich in architectural details characteristic of the 19th century was designed by engineer Vilhelm Dvoržak. From 1947 to the end of the 1980s, the original building of the District Post from the period of Austro-Hungarian administration changed its purpose, while the longest remained in it was the National Library (Figures 13). The building is due to no worries and the consequences of the subsidence collapsed in 2015.(18)

Figure 13 The National Library

Tourism today through the prism of subsidence

Tuzla has a very natural heritage, which can be used as its key comparative advantage to build an attractive tourist offer that will turn it into one of the most prosperous destinations of this part of Southeast Europe.(11) The story of the beginnings of a significant development of tourism in our city, started in 2003 after the construction of the first phase of the complex of the Pannonian Lakes, although the roots of tourism in the city of Tuzla date back to 1914, when the first spa Slana Banja was known in Europe for the treatment of various rheumatic diseases.

Salt as a natural resource whose exploitation for years destroying narrow city center, has been used as an advantage for the further successful development of the city. At the location of the Pannonian Lakes complex, it was once a part of the old city core, which, due to the uncontrolled exploitation of salt and intensive landfilling of the soil, was eventually transformed into an unregulated depression wetland without any content and purpose (Figure 14).
After the implementation of the phase I of the development of the complex by the construction of a large lake in July 2003, the stage development continued in 2006 by the construction of the Archaeological Park-Neolithic lake dwellings settlement with a museum setting that talks about the continuity of life in the city of Tuzla since the neolithic period. At the beginning of the summer season of 2008, the capacity of the complex was significantly increased by the construction of another salt lake, and at the end of September another unique tourist product was created - Salt waterfalls in the form of an inhalation health center in the open space. The third Pannonian Lake was opened on September 1, 2012.

The complex of the Pannonian Lakes is a total area of 75,000 m², the length of the coast is 1,000 m, the surface of a pebble beach of 22,000 m². Since the construction in 2003 to the present day complex is visited by over 3.5 million guests with an average daily visits of about 7,000 guests and with a maximum daily visits of about 15,000 guests. Salt lakes represent artificial accumulation of water inside the shells that are built from a combination of geosynthetic and natural materials (Figure 15).

Salt waterfalls are a special attraction on the complex, with five water cascades and two swimming pools, with the inhaling of the vapor of the salt water very favorable to the general improvement of health (Figure 16).
Figure 16 Salt waterfalls in Panonica complex

The specificity and uniqueness of the lake is the water that is filled and represents a combination of high-tech water and brine (300 mg/l) from saline wells from the Tetima pumping station. The salt water content in the total water volume is 30% with a salinity of 30-35 gr/l and which is always at the level of salinity of the sea water. In addition to salinity, the waters of the Pannonian Lake contain minerals (calcium, sodium, sulfur, iodine, bromine, etc.) and it is justified to have the image of "healing" water unique in our region and in Europe. In the area of cultural tourism offer, in complex Panonika there is Archeological Park-Neolithic lake dwellings settlement, a replica of settlements from the Neolithic period to nine dwellings, a wooden platform and internal setting tools, implements dishes for salting out salt (Figure 17).(7)

Figure 17 Archeological Park-Neolithic lake dwellings settlement

In addition to the complex of Pannonian lakes, as recreational and health center and tourist town is enriched regulation Salt Square as a museum and tourist complex, where at the time of the Turkish authorities carried out the exploitation of salt, where they are protected and learning available to tour the remains of the main the salt wells at that time (Figure 18).(7,11)
Figure 18 Exhibition of objects from the distant history of Tuzla
The Salt Square, together with the restored original saline well, was restored in 2004. In the square there is a replica of the Neolithic dish used for salting, which is part of the fountain, a tribute to the city of Ravenna, mosaic processed in the realization of the Instituto d'Arte Severini and world-renowned masters of mosaic Felice Nittou (Figure 19).(7)

Figure 19 Salt Square with saline well and a fountain

A special city attraction is the Freedom Square with a reconstructed Barok building and a large fountain (Figure 20).(7)

Figure 20 Liberty Square with the building Barok

**Conclusion**

Tuzla was created, developed and lived thanks to its fate related to the mining industry, especially for the production of salt. Throughout history, the influence of this branch on the positive and negative trends is monitored. At the initial stage, industrial and economic progress has been noticeable, to the phase
of decay in both literary and economic terms, i.e. deterioration due to subsidence and deterioration due to the closure of almost all industrial facilities in the post-war period. The process of settlement of the terrain is significantly reduced, and in some areas completely stopped, thanks to the activities undertaken in the mining industry, primarily suspension of uncontrolled secretion brine. Mining engineers work on constant calculations through projects and elaborates that select the most favorable method of exploitation. In addition, continuous monitoring is carried out for both the brine and the effects of salt extraction on the surrounding terrain and objects affected by the subsidence. Today there is a noticeable trend of attempts to develop in the field of tourism, and thanks to mining and salt, as a basic source of progress. The paper presents a brief overview of the changes in Tuzla through the history and through the prism of salt mining.

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