GeoJournal of Tourism and Geosites Year **X**, no. **1**, vol. **19, May 2017**, p.**82-95**
ISSN **2065-0817**, E-ISSN **2065-1198** Article no. **19107-229**

THE SPECIFICS OF ARHITECTURAL WATER INFRASTRUCTURE IN HERZEGOVINA KARST AND THE NEED FOR ITS PROTECTION

Snježana MUSA*
University of Mostar, Faculty of Science and Education, Department of Geography, Matice hrvatske bb, 88 000 Mostar, Bosnia and Herzegovina; snjezamusa@hotmail.com

Dario ŠAKIĆ
University of Mostar, Faculty of Science and Education, Department of Geography, Matice hrvatske bb, 88 000 Mostar, Bosnia and Herzegovina; dario.a.sakic@gmail.com

Abstract: As well as hunger, thirst is today, and throughout the history of the environment, a huge problem in many parts of the world. The thirst is conditioned by physical and physiological elements of the water body. In the area of Herzegovina thirst is the result of geological and geomorphologic frame. In fact, there is cca 1700 mm of rain per year, but very little is retained on the surface as a surface stream flow. This is Herzegovina karst, where the circulation of water is released into the underworld by numerous fracture systems, abyss, caves, estavela, etc. Humans and sometimes state built cisterns, wells and troughs for keeping this precious liquid. However, poverty of surface water is resulting in poverty and constant emigration of the population from these areas. Those who remained had to adapt to the natural features. Because of that, numerous elements are made for water collection, accumulation and use of water in Herzegovina karst. Today they are mostly abandoned. Their presence in the landscape makes it specific, and therefore, these objects have become our heritage. Unfortunately, in Herzegovina karst many of these objects are overgrown with weeds, and the water tanks themselves are damaged or even buried. It is necessary to do a project for their conservation as an element of national heritage. And habilitate at least some cisterns, which were built by the Austro-Hungary for the needs of herding in this area.

Key words: karst, čatrnje, cisterns, wells, heritage, Herzegovina

* * * * * *

INTRODUCTION

Only a small number of scientific institutions is engaged with karst over a wide area of Eastern Adriatic coast, where it is best developed. One of the oldest is the Karst Research Institute SAZU - Postojna, founded in 1929. In Croatia, the oldest institution has been the Institute for Adriatic Crops and Karst Reclamation in Split, which was founded in 1894, and it bears the name since 1964, and has an impact on the tradition with a variety of programs and intensity. Here is also founded the Center for karst in

* Corresponding author

Gospić, which has been designed as an institution that is supposed to bind all karst-related activities in Croatia. Also in 2007 was established Karst Centre of The University in Zadar. In Bosnia and Herzegovina, which has the largest area under the karst, there are no institutions that deal with karst. It should be noted that in the 2007 was established Center for karstology at Academy of Sciences in Sarajevo, but, for now, it is still only a declarative institution. Burden that is upon karst, which is influenced by exploitation of resources, is already extremely high, awareness of geo-ecological problems is at low level, but the need for new investment is growing and is increasingly demanding. Scientific and educational institutions in our universities are engaded with karst, but that work is limited to occasional research. The problem of water supply in Dinarides karst shaped the specific architectural aquati water infrastructure, which today represents our heritage.

THE BORDERS OF BOSNIA AND HERZEGOVINAS KARST

Dinaric karst covers an area that stretches from the Alps, along the eastern shores of the Adriatic Sea to the Drina river. Its heritage is shared among four states but the internal administrative and political division are the most complex in Bosnia and Herzegovina. Karst is a specific space for its petrological structure, by forms of relief that arise on and inside them, by water circulation and so on. Those are carbonate rocks, dominated by calcium or magnesium carbonate. Their solubility in water, especially one that contains carbon dioxide, is large. This, together with tectonics, is the reason for their cracking, porosity and the emergence of numerous forms of relief on the surface, but also in their interior (Oprea et al., 2012). In tectonic texture dominant role have reverse faults, and they have shaped relief scenes with many beams, ridges, plateaus and karst fields.

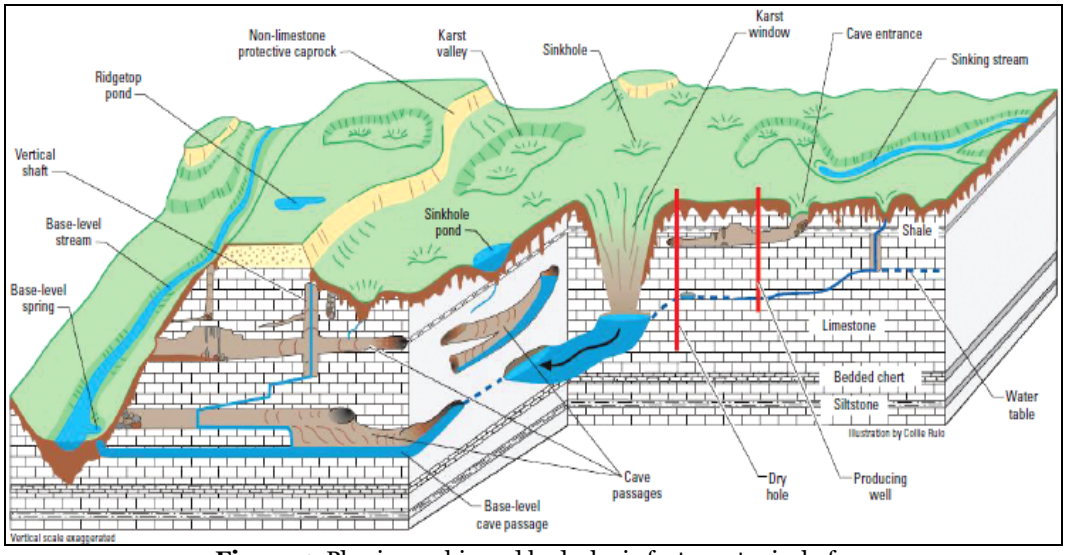

Figure 1. Physiographic and hydrologic features typical of a well-developed karst terraine (Source: Currens, 2001)

The egzogeomorphological forms include sinkholes, cracks, muzge, kamenice, doci, dolina, canyons, gorges, underground rivers, dry valleys, and in the underground caves and grottos. Many of these terms are entered into the world karst terminology (Figure 1). The area of karst in Bosnia and Herzegovina is defined by several authors, and no single point of view is the same: from 28% (Ostojić et al., 1979), then approximately 50% (Rzehak, 1965), followed by about 60% (Jovanović & Avdagić, 1981), and to 65% (Čičić, 1998) (Figure 2).

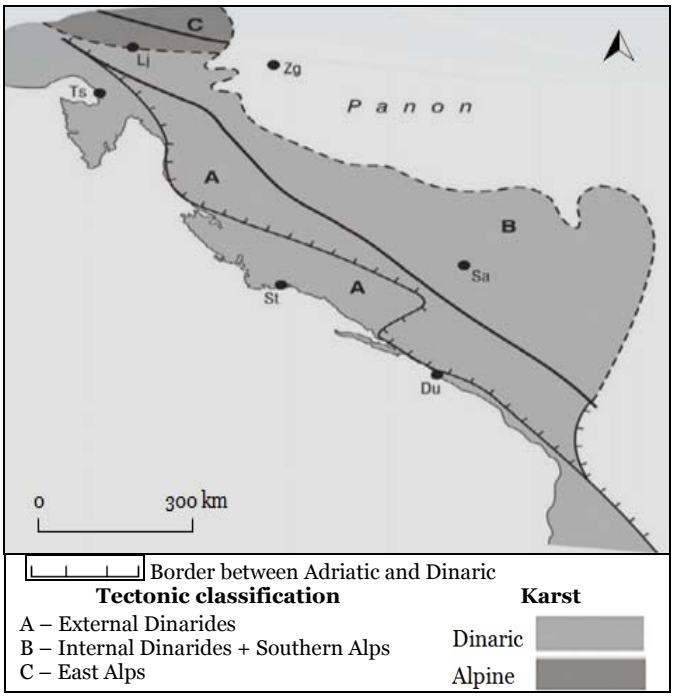

Figure 2. Tectonic relations in Dinarides (Source: Herak, 1957)

Figure 3. Characteristic coulisse relief

Figure 4. a) Karst plateau of Brotnjo and Dubrave b) Popovo polje – karst field in B&H

Dinaric karst is considered the largest unique natural value of Bosnia and Herzegovina. As a whole it contains significant elements of the world's natural heritage. Geological and geomorphological framework has determined the specificity of hydrological relationships. Water in these areas are rare occurance. The hydrological network is moved underground. It caused the man to adapt to those, not exactly hospitable, conditions of life. This is confirmed by the data on the largest emigration population precisely in the area of Mediterranean countries in which karst covers large area: Portugal, Spain, Italy and Croatia (especially Dalmatia and Dalmatian Zagora) and in Bosnia and Herzegovina (particularly Herzegovina), Greece... (Melelli, 2014). However, the values of Dinaric Karst are multiple: natural, economic, cultural, scientific, educational, recreational, etc. In previous geographic papers concerning karst in Bosnia and Herzegovina there were many exploarations including those of Katzer, Cvijić, B. Ž. Milojević, Dedijer, Roglić, Gašparović, Bušatlija, Bognar and many others (Bašagić, 1997), but it is still poorly researched. This particular concern is related to the underworld, which is the least explored of complete Dinarides.

Today the situation with the study of the underground karst is even worse, because the state, entity and cantonal borders led to the division both of the territory and financial funds for research. Lack of money and personnel for research were logical consequences and karst by its nature does not tolerate and does not recognize political boundaries. Today, Dinarides karst is being explored by country, so that every researcher is engaged in karst in their political determined borders. Knowing the structure of karst, it is clear that only an interactive approach to the problem and research in karst can result in prosperity. Geological boundaries of karst and still are not strictly investigated and it is a problem that has yet to be resolved (Figure 3 and 4).

THE USE OF WATER RESOURCES THROUGHOUT HISTORY

According to Sarvan (2013), the history of human society, in relation to the use of water resources, can be divided into three periods. *The first period* begins from the appearance of the human species about 14,000 years BC in which people used drinking water found in nature - in rivers, lakes and springs, and later they dug wells and collected rainwater cisterns, when the water was often missing and always a valuable resource, so valuable that it was holy to almost every human community. *The second period* began about the year 5000 BC when people are first starting to use primitive methods of irrigation of agricultural land on the plain of Mesopotamia. Subsequent advances in natural sciences, engineering and technology, around the year 1000 BC has allowed the abstraction of water from nature and the construction of artificial irrigation channels (Dugandžić, 2010). Later still, there are in use gravity and gravity-pressure water supply (Ancient Greece and Rome). This is the period of the Middle Ages, and new momentum continues during the industrial revolution in the 19th century.

Then, thanks to the new progress of science and technology, was developed technology of iron pipes, hydraulic pressure water supply and pumps for pumping ground water from great depths. Offset also brought chemical treatment of water, enabling access and enjoyment of water to a large number of households. In the late 20th and early 21st century began *the third period* dominated by the global water crisis. To the crisis contributed changed natural and social circumstances in the world (Fagan, 2011) as well as the appearance of discrimination against certain social groups (especially the poor) in the supply of drinking water in some countries (urban-rural population, the population of informal settlements, indigenous communities, minority communities , marginalized and vulnerable social groups). This period marks the beginning of the perception of water as an exhaustible and scarce natural resource.

SPECIFICS OF ARCHITECTURAL WATER INFRASTRUCTURE IN KARST OF HERZEGOVINA

Collecting rainwater is one of the ways of ensuring drinking water used by communities throughout the world. It is widespread especially in arid areas. The simplest form of collecting rain apply Nuer communities in Sudan in the way to collect water from rain in simple dug holes in the ground, which after the end of the rainy season is over are covered with a roof made of vegetation to prevent evaporation and contamination of the water. In Mediterranean basin, generally, collecting rainwater from roofs and its storage in stone cisterns is the usual way of providing enough water for drinking, but also in China and New Zealand and in other parts of the world (Robins, 1946). Lack of water in Bosnia and Herzegovina karst is linked to an area from Bihac to the Montenegrin border. There are mountains and fields with least water that are in winter turned to lakes and in summer they represent dry moonscape. In this area there were always strong emigration currents which is the reason that even today this area is in a way a demographic desert. Karst area has a very sensitive ecological habitus, and its protection is essential.

This problem in Bosnia and Herzegovina was recognized as far back as 1900 when the Law on the protection of karst underground was passed. But its implementation on the field is not so effective: pits and caves are dumps as well as riverbanks, field in karst Glamocko polje became polygon of federal army "Daring Barbara", where it destroys the tools and weapons together with supporting objects from the last war. How it manifests in the karst underground is a big question mark! The connection of natural and cultural artifacts in heritage is reflected in numerous elements. This paper analyzes the adaptation of man from the beginning of life in semi-arid conditions in karst Herzegovina. It is an area in the hinterland of the Adriatic Sea. Its function throughout history has been changed, but the conditions are mostly favorable for agriculture. Agricultural landscape is divided into two regions: Northern so-called The Region of High Karst for the substrate has deep karst. Its main feature is the lack of surface water. Under these conditions rotational herding is the dominant form of management. The southern part of the province is called Low Herzegovina. Fields in karst, underground rivers and the only river that from the source to the confluence is flowing on surface - Neretva, shaped the predisposition for agricultural relations. Coupling of these two regions has always been a transhumance-summer expulsion of cattle on the mountain.

Aside from the watersupplying facilities in the valley, history has shown that farmers made a number of objects for the collection of water, particularly with precipitation, in a wide area of the High Karst of Bosnia and Herzegovina. Stocks of of rainwater, collected in a short rainy season, were to last a long period to the next abundant rain. Heritage is our life through history painted with artifacts. It is divided into natural and cultural. One without the other can not exist. Natural is presented with relief, climate, waters, flora and fauna. All processes and forms of natural heritage would not be threatened if there is no man who adapts them for life on this earth (Adriansyah et al., 2015). Since in many societies cultural development known as one of the drivers in the development of tourism, both to increase the motivation for the research and preservation of the same. People from the earliest times of human development came together in reciprocal social relations related to the use of water for personal use and these social relations from the beginning demanded certain rules to ensure fair distribution of drinking water to all members of the community - the first rules on the use of water as customs and religious norms. Forms of architectural heritage for the collection of water are wells, pelvis (cisterns, reservoirs, tanks), kamenice and puddles (Figure 5).

Their existence is an essential source of information for the history of nations and regions, but also for the history of the language of the region. Unfortunately, washed up

areas as a surface to collect water many public wells, cistern and ponds are abandoned or overgrown with weeds, and the containers are damaged or partially buried. Pelvis and ponds should be trained not only the cultural and historical reasons, and the pleasure of attraction, but from the need to preserve drinking water.

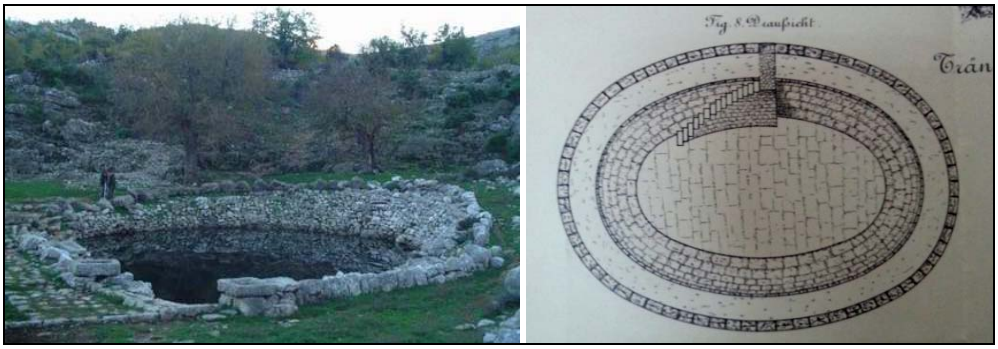

Figure 5. a) Well for collecting rainwater b) Scheme of well (Source: a) Author, 2011; b) Ballif, 1896)

Figure 6. Joint čatrnja from 1934 build by the state for population and cattle needs, Ošanići near Stolac (Source: a) Author, 2011; b) Ballif, 1896)

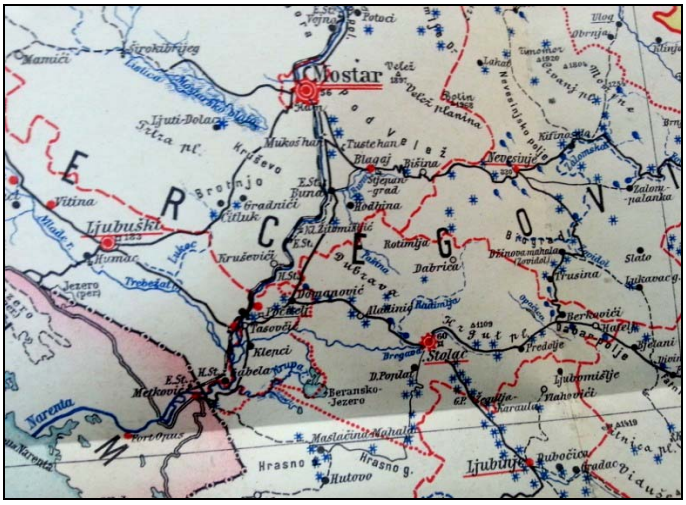

Figure 7. Ballif's map with topographic symbols for čatrnje and watter mills in Herzegovina (Source: Ballif, 1896)

Inventories of rainwater, collected in short rainy season, should be used until the following abundant rain. The first written mention of the cistern is located on pillar of Moab King Mesha, which dates from the year 865 BC (Franić, 1997). The text that contains thirty-four lines is one of the most beautiful examples of the use of Hebrew-Phoenician letters that have been used previously. However, cisterns were invented thousands of years before that . The secret cistern was found in Mycenae, in the fort, beneath the royal palace. The ancient Romans were great builders of cisterns, all the more because they already knew about the cement, similar to what we use today. In Herzegovina, the population is first used water for drinking and other needs from natural sources, which were gradually fenced and on them build common wells for one or more settlements, where more water could be gathered. For domestic use, people have dug cisterns for water (čatrnje). Their size depended on the type of country where it was dug and from the possibility of excavation. Everything was done manually, so it took a lot of manpower. At first it was filled with rainwater, which is collected with slanting slopes, and later from the grooves from the roofs of houses. Over the centuries the cisterns have enabled human survival on karst.

KARST CISTERNS, WATER TANKS OR ČATRNJE

In our region since ancient times, the water tank or cistern (čatrnja, gustirna, cisterna, nakapnica,... are the most common in waterless areas of karst (eastern coast of the Adriatic Sea to the hinterland). Originally, the tanks were (water tanks or čatrnje) hollowed out in stone and not beneath the building but the location was conditioned by any possibility of adding water or impermeability of the field. Elaboration of this is the idea that people get by looking at the various natural reservoirs: ponds, small periodic lakes and similar. Word čatrnja (*cistern)* is of Hungarian origin and originally it represented a pit that is dug in ground where water from rain and snow was collected and kept. In Herzegovina region there are tens of thousands of water cisterns which commoners, with a lot of effort, dug and established in the nerve of the stone over a hundred and more years. Since it is an area that is characterized by dry periods during the year, and where natural sources waters are limited and a long distance away from home, regular water supply has been resolved with these cisterns. The oldest tanks were in Herzegovina rarely near the house, and almost never inside it. „Gustirna“ was eroded in stone. The invention of cement and other civil engineering materials, led to the construction of public cisterns, of bigger displacement in the villages and towns. At that time washed up areas of such tanks (slanted collector surface of each well-connected smooth stone slabs, surrounded by a wall) often covers a very large area, sometimes a considerable part of the hill, for example in Stolac, Buna, on Bjelašnica (Figure 6).

Scientific research and importance of the tanks is not only related to the heritage. For thirty years in Croatia there is an on-going investigation of radioactivity in tank waters (Franić & Petrinec, 2006). Tank waters are great cumulative collectors of the so-called radiactive fallout. This concerns radioactive material either of natural or artificial fission which has been, through human activity, entered into the atmosphere (atmospheric nuclear testing activities or nuclear installations). Fine particles of that material for years remain blocked in the stratosphere, and continuously, in small amounts, are deposited over the entire globe. These are very, very small activities that can not be detected without extremely precise instruments. For human health, such small activities are harmless, but they are extremely interesting to scientists. Such data helps in mathematical modeling of water circulation in nature, as well as the determination of various atmospheric parameters. Immediately after the nuclear catastrophe in Chernobyl, dozens, even hundreds of samples of tank waters along the Adriatic coast were taken. And exactly these samples showed that

the eastern coast of the Adriatic Sea was not directly affected by any of the three radioactive plume which spread through Europe as a result of the explosion and fire that raged for nearly two weeks in a graphite moderator of ill-fated reactor. The reason behind that is that the former meteorological conditions went in favor of east coast of the Adriatic Sea.

Samples of tank waters have, in addition, helped that Croatian scientists establish the approximate composition of the Chernobyl reactor before the official statements of the then Soviet Union and the United Nations (namely the International Atomic Energy Agency - IAEA). Today it should be initiated a research to determine the changes caused by uncontrolled interventions of water from deep bores with strong pumps and their consumption. Originally, gustirna (tank or cister were chiseled in stone instead of beneath the building but the location was conditioned by the possibility of adding water or impermeability of the field. Oldest cisterns are rarely near the house, and almost never in it. „Čatrnja“ an be positioned in the yard or on the terrace, and often behind the house. Their size is dependent on the type of land and the possibility of excavation. Everything was done manually and it took a lot people and passion to dig it up. At first it was fiilled with rainwater, which was collected with slanting slopes, and after from the troughs of the house. The oldest of such and with the best water are those in the courtyard or garden, or where there is the smallest exposure to the sun (Ostojić, et al., 1979). Often its upper surface that turns into a lovely terrace covered in trellis, which provided additional protection from the sun.

Joint cisternas (čatrnja)

A special form of cisterns (čatrnje) in karst are joint cisterns. A special form of čatrnja in karst are joint čatrnje. They are a result of the need for wattering livestock. They appeared along with modernization of construction in Herzegovina villages, and they had a larger volume. Therefore, the washed up area of such cistern „čatrnje“, cupied a large surface, often even a considerable part of the hill. That is how „čatrnje“ were no longer related to the 'alive' stone, but preference is given to practicality. But building čarnja in modern age of Herzegovina karst is very expensive. That is why people repair and maintain the old čatrnjas built in solid stone. Some of the čatrnja in the old Herzegovina are more than a century old and are originally a folk treasure. In the old times they had to be locked and well kept, because water loss would mean the end of life. Today, the old čatrnje are a simbol and testimony of an era and life in it. How great was the importance of collecting these waters is evident on the basis of cartographic documents. As one example there is a map of Ballif (1896) in which he lays particular emphasis on čatrnje and a water mill as well as on the irrigation systems (Figure 7). In the medieval town of Ljubuški, in internal, northwestern part behind the entrance, two defensive towers and čatrnja were built. Unlike the karst lowland areas (karst fields or some of the karst river valleys), where larger number of karst springs of higher yields appear and where there is water even for irrigation and other uses, in karst mountainous areas water is a scarce and precious resource. Bjelašnica is a part of Dinaric mountain range and falls under a group of anhydrous mountains of Dinarides. On Bjelašnica there are villages that are located primarily in the southeast, southern and southwestern slopes, and together they are called "Zabjelašnica" or "zabjelašnička villages". The western part of Bjelasnica is rich with relief karst shapes: škrape, ponikve and uvale on the limestone and dolomite base, and that is the typical karst. Even on Bjelasnica in the beginning the stone was a building material for the tank. Area for capturing rainwater was being built on the soil surface and immediately adjacent to the reservoir. It was paved, crammed with soil or in later years concreted, and set slightly tilted to the tank of čatrnje. Čatrnje were built in settlements along the roofs of buildings, in the fields for watering of livestock. Often the whole village had a major central čatrnja, like for example village Čuhovići, where today there is central rural čatrnja, but it is not in use. There is visible an engraved year of construction – 1937. The diameter of annular area for

collecting rainwater is about 30 meters. What was in settlements with spring water a sink / faucet in the village center, in anhydrous settlements it was the central čatrnja. In addition to this central čatrnja usually every household had one of its own. The main characteristics (determinants) on the basis of which we can make classification čatrnja, is the way in which rainwater is collected, ie the difference in the construction of area for the collection of rainwater. On the Bjelašnica mountain was developed a specific way of collecting water: in a pit is placed a kind of wooden pipes, such as hollow oak trunk which accumulates the water. According to the method of capturing rainwater čatrnje are divided into five types:

- Čatrnje which have small space area for capturing rainwater. This area was once impaled with soil, and later paved and slightly tilted toward the tank. This type of Čatrnja has no walls around the area for capturing rainwater.
- Čatrnje that used as the surface to collect rainwater the roof of the house, summer pasture and cattle stables. The roof of the house with an open hearth or home that has a brick chimney were never used, because the smoke from the fire would give water / rainwater in the čatrnja bad taste. The rain water was not potable.
- Čatrnje whose surface for collection and accumulation of rainwater and snow ispaved and walled around (pool). Such cistern still exist on the southern edge of Šišan fields and on the plateau of Dubrava near Stolac on Ošanići.
- Čatrnje that do have no or have very little area to collect rainwater, and some čatrnje have only a tank (buried part) with an opening.
- Brick čatrnje ("kameni ćemer") - method of building ćemer: stone masonry has conical or pyramidal shape, and during building the "stone to stone" is reduced (tapered) to the top and when it's "reduced to plug" at the end it is fitted with capstone that called "cap". On the interior walls then goes a syringe, a formulated binder of lime and fine river sand (from the Neretva or Canyon), so she gave the hardness to walls. On the whole area we found only one such brick čatrnje, on the way from Vrdolje to Lukomir. Often among people there are stories on how the natives closed sources of water, cisterns, and wells with ox hides, and the water was carried in barrels on donkeys or even on humans (Figure 8).

Wells or well springs

Wells are actually water traps that were dug in the ground. Well that was dug is coated or built of stone blocks to prevent the landslide and backfill of the well. By construction technique, it can be determined to which period the well belongs. The most beautiful are those from ancient times. The faces of the walls were made of the proper and orderly carved stone blocks, and an empty core wall is piled with stones mixed with lime mortar. According to the method of construction, the oldest wells are attributed to the Greek and Roman builders, and most of them are from antiquity and late antiquity. On the territory of Bosnia and Herzegovina technical achievements came from the south and from the north. They came from the area of the Mediterranean, Arabian, Far East and Turkey, and then through ancient Greeks, the Romans, Fenice till the late Middle Ages. Since then to the bourgeois revolution, technological progress comes from the north, and that in this area means the Austro-Hungarian. One of the oldest archaeological finds is related to hydro facilities on the territory of Bosnia and Herzegovina is related to the region of Ljubuški for Roman camp Gračine. There namely, archaeologists have found the so-called Archimedes screw with which water is pulled in the inner basins. It is very interesting position of the well-čatrnje, in the Illyrian city of Daorson. Daorson was the capital of the Hellenized Illyrian tribe Daors who lived from 300th to 50th BC in the valley of the Neretva River. The remains of this once the most powerful city in the wider area are located in Ošanići, near Stolac in Herzegovina. It was composed of three parts, of which the central one was the fortress - acropolis, which was surrounded with "Cyclopean" walls of huge stone blocks (similar to those in Mycenae in Greece).

Figure 8. Making friendship on čatrnja in Herzegovina (Source: Kahn, 1912 ; http://4.bp.blogspot.com/-4HB A4 sxSWno/UoJcyLRtUxI/AAAAAAAAAtE/tY- _RBu_ Nb4 /s1600/Buna,+čatrnja+(Albert+Kahn)+21.10.1912..jpg)

Figure 9. Batismal well in Livno, the archaelogical site Lištani (Source: Commission to preserve national monuments)

Figure 10. Joint pond and dry stone wall as a boundary plot in Duvanjsko polje (Source: Misilo, 2009)

Figure 11. Through (Source: Author, 2011)

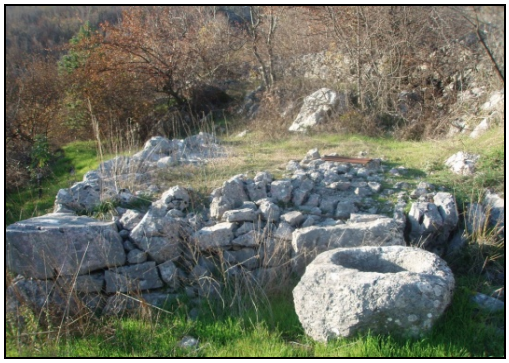

Figure 12. Kamenice in Bogodol (Source: Author, 2011)

Figure 13. Mills on river Bregava in Stolac (Source: Author, 2011)

Baptismal well is a specific element of the Christian tradition. In the early Christian rituals different words were used for baptismal font, therefore a vessel for christening, in which the baptized was dipped during receivement of holy baptism, and the building of baptisterium, in which were housed one or more baptismal fonts. By construction technique, it seems, that Studenac belongs to late Roman period (4th to 6th

century) ie. to the construction *opus quadratum* (Dugandžić, 2010). In this case, faces of the walls are made of properly and neatly carved blocks of stone, and in the empty core of the wall are piled stones mixed with a furnace mortar (Figure 9).

Puddles

Water scarcity affects both humans and animals. Mostly engaging in the production of livestock on waterless mountains of Herzegovina prompted the people to use natural or to upgrade and maintain semi-natural and artificial ponds. They kept water in them by piling up a layer of clay in natural karst depressions, so that rainwater would not be lost. Almost every town in Herzegovina has had their pond which in the past had a greater role than today. Once these were the only sources of supply of goods and agricultural irrigation. Usually there were three sides built, with partially carved stone (with Klačno mortar) and the side without the wall is an entry for livestock (Figure 10). Ponds are important for living diversity of each environment. They are the trademarks of the former Herzegovinian landscape. they represent habitats of many amphibians, insects and wetland plants, so they must be protected, because if they grow out, all the plants and animals that live in them, will disappear. The stay of cattlemen from the low-Herzegovina in the mountain would lasted until the first autumn rains, when the pastures in the valley are restored and it's the time when the flock goes back to their villages. Cattle grazing in the mountains, collecting and processing milk and wool meant a continuous stay of herds and those who cared about them for about four to five months.

Through

Through is usually an integral part of a well or čatrnja (cistern) (Figure 11). Rainwater or snow were collected in the upper part of the cistern. The lower part of the river, was used for watering the goods. Throughs of Herzegovina have the usual shape of a crown which is the same as in Primorje (coastal region), and they do not have a hole through which water is drawn. It is a rare phenomena that sinks have decorations or inscriptions. Unfortunately, some of the throughs were formed from the tombstone, originally a stećak, which was later converted into a through. Middle Ages certainly had a special wooden innovation. This is confirmed by numerous calcified throughs that are found buried once one starts to build the trap springs. This is an example of springs under the drum on the Gvozno polje on Hrbljina plateau. Some waterbeds are built of wood. Most of them are destroyed. Sometimes you can find a calcificated through on the place where a new well is being dug. Waterbeds are connected with drinking fountains. Its meaning had a specific position on our mountains with arrival of Islam. Hair fountain were built, as the foundation of wealthy residents. This custom has been retained to this day.

Kamenice

In Herzegovina, on a plateau, there was no current water nor springs, and the landforms are often used as water findings. Kamenica, where for some time after the rain there could be found water, often saved both humans and animals of thirst. These kamenica could be found in many places. It was a small hole in a stone boulder. In this recess there can fit two fifty liters of rainwater. It provided the animals with water as well. Kamenice can sometimes appear as a man-shaped small fountain in stone. Considering that the cornerstone is a healthy material that maintains long freshness, kamenica was also help to shepherds in extinguishing their thirst (Figure 12).

Architectural aqual infrastructure also includes waterwheel, mills and stupe

Waterwheel or mill used to be a very important economic facilities, whose purpose was to grind grains of all kinds and transform them into the most basic foodstuffs. Today they are in the period of dissolution. In rare cases they have been reconstructed as a single historical monument or as part of a cultural milieu, mostly for tourism purposes. The two most common name used for this type of traditional economic structures are: waterwheel

or mills / mill. In karst regions mills were built of stone of sedimentary origin, usually limestone. The frame doors and windows, as well as the angular stones are of finer treatment in order to give the object strength. The cover on the mills is of stone slabs and roof structure is timber. In the 20th century newer materials are used for cover: tile or sheet. Vodenice attract the attention of many travel writers and researchers who have visited Bosnia and Herzegovina, such as Evans (1965). There are several examples of positioning watermill on the karst streams, namely: a small mountain streams, larger karst streams, on karst springs, in karst sinks, and watermill in urban areas. What is the same for all of them, is that water powers them all. In town of Stolac on the river Bregava there was a large number of mills some of which are partially preserved today, but in a state of ruin (Figure 13). Stolac was one example of the urban environment where there were built mills completely harmonized with the natural environment through and the rest of the architecture in the city. In Extensive list of the Klis sandžak from 1550 in nahija Livno there were a total of 55 mills. On the river Bistirica there were 22 mills on the which was paid tax mill "resm-and-asijab" by 30 akčas per year (Spaho et al., 2007). With Turks there came dolapi, a wagons for irrigation. Dolap or wagons are used for irrigation of arable land, and they are common artistic motifs and part of the postcards. Today they are forgotten and there is not a lot of them. Only on the river Trebišnjica from the mid-19th century, there are written records of Trebinje wagons, but they, had to appear at the beginning of the 18th century. Only on Trebišnjica river there were 60 of them to date.

Artificial lakes for collecting water in karst

Lake Klinje was accumulated from 1891 to 1896, with the construction of the stone arch dam in valley below the bulkhead essay of rivers Vrba, Dramešina and Žanjevići. Arch dam was designed and built under the instructions of the French engineer Krantz. It was 26 meters high, its upper width was 4.6 meters and and on the base 16.7 meters. Its length was 104.5 meters and it contained 9,504 cubic meters of material. For its construction they brought volcanic ash from Mount Vesuvius in Italy, which served as a binding material. The dam was built for irrigation of Gatačko field. At the time of the great flood on October 13, 1975, the crown of the dam was damaged and rebuilt in 1982 and 1983, and then the equipment and facilities at the dam were reconstructed. A few years ago Government of Bosnia and Herzegovina recieved a written notice from Austrian Ministry of construction that has expired 100 year warranty for the construction of this dam. There is no doubt that this building deserves to be a national monument.

Figure 14. Building Klinje dam (Source: Renner, 1896)

Channels for traditional irrigation

Residents of the river valley Drežanka used water from Drežanka for different purposes and in different ways (Stojaković, 1982). The best known way of using water are

dug irrigation canals ("soak") of small and scarce farmland. The Mediterranean climate impacts that extend from the south through the valley of the Neretva River, penetrating the valley Drežanka, and they are especially felt in the lower reaches around its mouth. This leads to the dry summer period, in which Drežanka does not dry up. These dry summers and arable land that are located relatively close to the river forced the residents of Drežnica to manually, completely without the help of modern machinery, dig canals, or rather a network of channels, along the river valleys of Drežanka (Renner, 1896). Such irrigation created better conditions for agriculture. Drežnica was even in the middle ages been known for exporting its grain to Dubrovnik as indicated by some written documents from the second half of the 14th century which mentions the sale of grain to Dubrovnik by Radoslav Mesnovića from Dreznice, and it is assumed that it is a grain that he exported from Drežnica (Niškanović, 1983). There are several names for channels: gully, zlib (groove), gutter, jaz. Channels are social, rural good. The principle of allocation and use of water from the canal was determined already during the construction of the channel.

Property relations in this valley are such that attention is paid to each parcel had access to the river. The width of the output is called "forehead". The right to water was given to all those who took part in the construction ie breaking through the channel (Belamarić, 1999). The distribution was prepared and carried out in a traditional way: on the "forehead" (time interval irrigation). Two forehead were 24 hours, one brow was 12 hours - day and night, half a daywas forehead. The time was determined by the position of the sun in the daily distribution, and the position of the stars of night distribution of water from the canal. In the village Bunčići there once existed stones ("markers") that followed their shadow during the day. It was solar clock meant for timing of "order" for users of irrigation channels. Over time the arable plots were cut by inheritance, and how the clock was more and more commonly being used to measure the time, so the appearance of clock soaking time "melting" was measured per hour (60 minutes). When inheritance or sale of land that had channels, or through which there were dug canals, a common law was used. The right to water is gained through contribution and participation in the construction of the channel, and that right is passed from the old to the new owner together with the land that is bought or inherited (Palavestra, 1982; Stojakovic, 1982).

CONCLUSION

All these objects in Herzegovina karst are now threatened. Animal husbandry is disappearing. There is almost no tradition of expulsion of cattle on the mountain. There is no local population so cisterns, fountains and ponds are not repairing. We hope that they will find a way for registration of architectural heritage of water infrastructure in karst through certain cadastre, and thus easily restored, protected and evaluate for purpose of tourism, economy or nostalgic mountain walks. Due to the practical needs for accessibility of water in Herzegovina karst, but also due to the economic valorization of the same, every activity to raise awareness about the importance of this heritage is necessary. With hunger, thirst is also still a huge problem in many regions. There are many people who can not afford a single glass of fresh water per day. The most vulnerable are, as always, children and the infirm. It is unfortunate that today, in era of Agenda 21, the action plan for the 21st century that was adopted five years ago in Rio de Janeiro, and which advocates sustainable development and rational management of natural resources, people seem to know less (or what was worse, simply care less) about some of the problems that have been successfully handled by people thousand years ago. Among other things, in Agenda 21 in the part relating the management and use of water resources stands: Modern technologies, including the improvement of indigenous technologies are needed regarding the full use of limited resources of water and protecting those resources from

the pollution. Unfortunately, washed up areas of many public water tanks are overgrown with weeds, and reservoirs themselves are damaged or even partially buried. Should it not to considered, as part of the development of infrastructure of the coast and the islands, a re-training of many of our tanks and not only because of the cultural and historical reasons ie as a tourist attraction, but also as a valuable system in case of need that may provide something more precious than gold: fresh drinking water.

REFERENCES

Adriansyah, D., Busu, I., Eva, H., Muqtada, M., (2015), *Geoheritage as the basis for geotourism development: a case study in Jeli district, Kelantan, Malaysia*, Geojournal of Geotourism and Geosites, Year VIII, 2015 / 1, Volume 15**,** ISSN 2065-0817, e-ISSN 2065-1198

Ballif, P., (1896), *Wasserbauten in Bosnien und der Hercegovina, 1 teil, Meliorationsarbeiten und cisternen im karstgebiete*, Druck und verlag von Adolf Holzhausen, K. Und K. Hof- und Universitäts-buchdruckerm, Wien.

Bašagić, M., (1997), *Prilog historijatu istraživanja krša u Bosni i Hercegovini – The contribution to history of investigations of the karst area in Bosnia and Herzegovina*, Naš krš, XVII, 30, Sarajevo, 29 – 39.

Belamarić, J., (1999), *Dioklecijanov akvadukt i njegove obnove*. U: *Dioklecijanov akvadukt*, Ministarstvo kulture Republike Hrvatske, Split.

Currens, J., C., (2001), *Generalized block diagram of the Western Pennyroyal Karst*, Kentucky Geological Survey, map and chart 16, series XII.

Čičić, S., (1998), *Karbonatne facije u geološkoj građi terena Bosne i Hercegovine : Carbonate facies in geological constitution of the terrain of Bosnia and Herzegovina*, Naš krš, Sarajevo, XVIII, 3–37.

Dugandžić, I., (2010), *Kamen i voda, kraški izvori u Rašanjskom polju*, Hrvatsko društvo čuvara baštine, Rasno – Široki Brijeg.

Evans, J., A., (1965), *Kroz Bosnu i Hercegovinu peške tokom pobune augusta i septembra 1875*, Veselin Masleša, Sarajevo.

Fagan, B., (2011.), *Elixir – a History of Water and Humankind*. Bloomsbory Press, New York.

Franić, Z., (1997), *Cisterne što život znače*, Hrvatski obzor, 128:38

Franić, Z., Petrinec, B., *(2006), Marine radioecology and waste management in the Adriatic, Archives of Industrial Hygiene and Toxicology, 57, 347 - 352*

Herak, M., (1957), *Geološka osnova nekih hidroloških pojava u dinarskom kršu* (*Geologische Grundlagen einiger hydrologischcn Erschcinungen im Dinarischen Karst*), Zbornik 2. Kongresa geografa Jugoslavije, Sarajevo, 523-539.

Jovanović, R., Avdagić, I., (1981), *Neka pitanja o razvoju i hidrogeološkoj funkciji karstnih polja: Some metters concerning the development and hydrogeological function of karst poljes*, Naš krš, Sarajevo, VII, 10–11, 55–78.

Melelli, L., (2014), *Geodiversity: a new quantitative index for natural protected areas enhancement*, Geojournal of Geotourism and Geosites , Year VII, 2014 / 1, Volume 13 ISSN 2065-0817, e-ISSN 2065-1198

Niškanović, M., (1983), *Porijeklo stanovništva Drežnice*, Glasnik Zemaljskog muzeja u Sarajevu (Etnologija), Sarajevo, 127 – 180.

Oprea, R., Nedelea, A., Comănescu, L., (2012), *Petrographic relief in the Bucegi (Prahovean area) and Ceahlau mountains (Central area) – the Romanian Carpathians. Scientific aproach vs local legends*, Geojournal of Geotourism and Geosites, Year V, 2012 / 2, Volume 10 ISSN 2065-0817, e-ISSN 2065-1198

Ostojić, Đ., Srdić, R., Torbarov, K., (1979), *O stanju hidrogeoloških istraživanja i ispitivanja u Bosni i Hercegovini*, in: Savjetovanje o stanju i pravcima razvoja rudarske i geološke nauke u Bosni i Hercegovini (1976–1985), Tuzla, 21th of december 1977., ANUBiH, Posebna izdanja, XLIX, Odjeljenje tehničkih nauka, Knjiga 9, Sarajevo, 512–522.

Palavestra, V., (1982), *Drežnica u Hercegovini-zabilješke o prošlosti i narodnoj kulturi*, Hercegovina, Mostar, no. 2, 91 – 123.

Renner, H., (1896), *Durch Bosnien und die Hercegovina - kreuz und quer*, Geographische Verlagshandlung Dietrich Reimer, Berlin.

Ržehak, V. (1965), *Speleological curiosities of the Bosnian and Herzegovinian karst*, Naše jame, Ljubljana, VII/1965, 1–2, 73–77.

Robins, F., W., (1946), *The Story of Water Supply*. Oxford, University Press.

Roglić, J., (1969), *Geografski aspekt Dinarskog krša*, Krš Jugoslavije (Carsus Iugoslaviae), vol. 6., 19 -38.

Sarvan, D., (2013), *Pravo na vodu kao povijesno nasljeđe čovječanstva*, Hrvatske vode, 88, 131-140

Spaho, F., Dž., Aličić, A., S., Zlatar, B., (2007), *Opširni popis Kliškog sandžaka iz 1550*, Orijentalni institut Sarajevo.

Stojaković, V., (1982), *Etno-socijalni okviri života stanovništva Drežnice*, Glasnik Zemaljskog muzeja u Sarajevu (Etnologija), no. 37, Sarajevo, 189 – 219.

Submitted:	Revised:	Accepted and published online
07.10.2016	24.02.2017	27.02.2017