HYDROECOLOGICAL PROBLEMS IN SARAJEVO BASIN

Muriz Spahic, Emir Temimovic and Haris Jahic
University of Sarajevo, Faculty of Mathematics and Science, Department for Geography
Zmaja od Bosne 33-35, Bosnia and Herzegovina
murizspahic@gmail.com emirtemimovic@yahoo.com haris-jahic@hotmail.com

During the year of 2016, the residents of Sarajevo were faced with the problems of proper water supply. Problems would be tolerant for extremely arid year, which can be normal occurrence in moderately warm and humid climate which is present in Sarajevo basin and on the mountain plains that gravitate to it. Year in question was considerably humid with increased rainfall, which forms vadose contact in river systems that drain toward the river Bosnia, the main hydrological backbone of Sarajevo basin and its surroundings.

The emergence of water shortages for water supply has caused great attention of citizens and the scientific community, which was the subject of public debates launched by civic associations, in which actively participated the Association of Geographers in Bosnia and Herzegovina, to explain the shortage of water in the water supply infrastructure. Public debates on the subject revealed profound problems concerning water supply of Sarajevo. They are the result of the genesis of the aquifers in the Sarajevo basin; intergranular ones in Quaternary facies and karst fissured ones in the carbonate facies formations of Igman and Bjelasnica. The synergy of hydrological relationships and connections forms the main water reservoirs in the Sarajevo water protection zone from which the water is taken and through the water infrastructure transported to consumers in Sarajevo. Since this is a large basin area, which is anthropogenically usurped, vadose waters can get contaminated and worsen the state of water protection zone. In addition, there are intentions of decrease of the area of water protection zone, which will greatly exacerbate the problems of waters in it.

Keywords: groundwater, intergranular water, karst, karst water, aquifers, fracture porosity, environmental problems, water supply, sewage, sewerage.

INTRODUCTION

Hydro ecological problems significantly affect the security, accumulation, distribution and consumption of water for water supply purposes. It, among other things, includes balancing the necessary waters for the water supply which includes the available amount of rainwater, their losses through evapotranspiration and infiltration, whether in terms of biological, rock or anthropogenic consumption.

Balancing water resources is being multiplied, if we take into consideration the waste or contaminated waters, with tolerable concentrations of biological and chemical contaminants. In that case, the required amount of surface water must be increased by ten times to dilute agents in the tolerable limit, so they could be distributed to consumers through water supply, after the additional treatment and conditioning (Spahić, M. 1999).

To consider the hydro ecological problems of water supply of Sarajevo, it is necessary to define the genesis of water in the Sarajevo basin, then its volume measured at the outlet profile of Bosnia river, which makes the hydrographic backbone; the main drainage of Sarajevo basin. In addition, it is necessary to determine the groundwater in the Quaternary

sediments of Sarajevo basin which are closely related to karst fracture waters of carbonate facies in hydrogeological formation of Bjelasnica and Igman. These waters are separated by the Busovaca tectonic fault (Spahić, M. 2013).

By the tectonic contact the carbonate mass of Bjelasnica and Igman is quite stable to the quaternary molasse mass of Sarajevo basin, which is located high above the karst-corrosion bottom hydrological base from which, in part, the water enters the intergranular wells or is discharged onto the topographic surface through the springs and it forms surface flows, from which the most important ones are the ones that form the river of Bosnia.

Drainage areas, from which are drained the surface and underground karst waters, are being usurped anthropogenically by the urbanization and municipal infrastructure since the time of the 14th Winter Olympic Games. In the last decades without serous spatial planning solutions, usurpation was continued, which caused the number of negative tendencies, especially in sewage infrastructure which caused uncontrolled and continuous discharge of sewer water that ended up beneath the ground, and then directly through the fissures got mixed up with karst waters and ended up at the springs of the Bosnia river. The Institute of Public Health of the Sarajevo Canton has been warning about this phenomenon with the proposals, to place a signboard at the main spring of the Bosnia River which would warn that the water is not potable, but the proposal has never been taken into consideration.

In order to address the theme and title of work, we used methods of scientific empiricism, field prospecting, content analysis, cartographic methods, hydro ecological monitoring and others. On the basis of mentioned methods we perceived all the problems that are primarily related to the method of providing and usage of water resources in the Sarajevo basin. In addition, the paper used texts of warning the authorities of Sarajevo Canton about the problems of water supply, instead of talking about the fabrication of drinking water for the export in the Sarajevo basin.

THE GENESIS OF WATER IN SARAJEVO BASIN

Fracture waters

Fracture waters are infiltrating rainwater systems which through systems of cracks, fissures, caverns and cave channels end up beneath the ground through which they flow by gravity and hydrostatically toward the best places of efflux from karst underground to the surface. These are special karst systems whose lower karst base is defined by the depth of karstification of carbonate morphostructures of Igman and Bjelasnica. They represent a unique carbonate (limestone and dolomite) block, which subductivelly ends beneath Quaternary deposits of Sarajevo basin, in the northeast.

Carbonate formations that build mountain morphostructure of Dinaric interides, to which, among others, belong Igman and Bjelasnica, link their genetic geological evolution from the Mesozoic period, mainly Triassic in which the earliest sedimented Werfeninan facies are composed of sandstone, marl and clay deposits. Werfen is a hydrogeological insulator that defines the lower karst base of fracture waters.

Shallower facies of Igman and Bjelasnica are built by dolomites and limestone of Anisian floor, which is usually tectonically shattered and thus karstificated with fracture porosity, through which the groundwater circulates. Anisian floor is hydrological collector. Above it, as the roof seam layer, continues the Ladin floor of lithofacies: shale, chert, tufose

sandstones and limestone silicified with chert, which are sufficiently hydrologically resistant when it comes to leaching of karst waters toward the lower floors.

Above the facies of Ladinian floor, built in form of super position are limestone and dolomite of the middle and upper Triassic and then megalodonic Upper Triassic limestone, and in some places facies of Jurassic-Cretaceous flysch are met. Roof seam sediments are developed in Quaternary, mainly Pleistocene fluvial-slope one, and according to some (Cvijić, J. 1889) fluvial-glacial facies, which is covered with a thin bark of soil substrate.

Carbonate surface layers are karstified, as evidenced by the present morphosculptures of which the most evident ones are: cracks, sinkholes, dry valleys, caves and grottoes. They all contribute to the karst aridity in which the surface hydrographic network was transferred to the karstic interior. In a collector karst series surface waters form separate karst hydrological systems in which the lower karst erosion base is determined by the Werfenian geological layers.

Fracture and cavernous collector karst hydrological systems are rich in water the most in a series of Middle and Upper Triassic, which descends toward the Sarajevo basin along parallel tectonic fractures in the form of step-structure with Dinaric direction. In this way, the mountain morphostructures of Igman and Bjelasnica, toward the Sarajevo basin form the system of zagate karst (Jovanovic, R., Avdagic I. 1981), which was formed, due to specific conditions, with the sinking of carbonate series – mainly isolated limestone blocks, which were then masked by the younger Neogene and Quaternary geological formations below the recent topographic surface of Sarajevo basin. Neogene and Quaternary molasses of Sarajevo basin cover the ingression carbonate formation by the powerful layer of depth to 70 m, and in some places as the site of Kovac to 180 m. With moving away from the slopes of Igman toward central parts of Sarajevo basin the depth of molasses layer increases up to 320 m. The thickness of the layer of Tertiary Miocene-Pliocene deposits is undoubted evidence of subsidence of Sarajevo basin along the tectonic ruptures among which the most important one is Busovacki fault.

The process of karstification started after the completion of fracture tectonics and gradually descended toward the lower karst base, which depended on the depth of the previous tectonic fractures and the intensity of the molasses income in the predisposed surrounding of today's Sarajevo basin. With this and the karstification of limestone-dolomite series, karst gravity sources were transformed into springs, whose waters are discharged to the molasse deposition of which the hydrographic system of the river Bosnia was formed.

Karst waters of Igman and Bjelasnica are vadose ones that from the area of about 1000 square kilometers and are being infiltrated through the karst systems into the carbonate mass and directed towards the springs at the base of Mount Igman. They mainly supply spring waters which are formed in a loose series of sediments of Sarajevo basin.

Infiltration of surface waters and their flow through a series of karst channels is carried out through the separate hydrographic systems, where they have no connection with each other. The most significant one is the one on the profile Sitnicka lokva – Bosnia springs for which the dominant was the role of orientation of Brezovacki fault opposite to the Dinaric direction. Independence of karst systems is confirmed by the thermal differences in water sources at the base of the Mount Igman. Based on the difference in the temperature of water in springs at the bottom of Igman on the edge of Sarajevo basin opted T. Kanaeta (1962) to correct the traditional hydronium ''Spring of Bosnia'' to the ''Bosnia springs''. On the basis of the thermal difference in the emerging waters the same author believed that the series of

springs of Bosnia does not come from the same karst recipient so that they can be considered the springs of broken karst type.

Karst process in limestone block of Igman is in a very advanced stage, as evidenced by the fact about the fluctuations in flow of water through the karst cracks. So, Brezovacka crack, which is directed towards the Bosnia springs, can omit up to 25 m^3/s of water. The minimum amount of rainwater is 1.4 m^3/s and it occurs after the hydrological minimum of surface streams. Maximum and minimum flows through karst cracks are retention compared to periods with a maximum or minimum amount of rainfall. Delay of extreme flow after the extreme rainfall is the result of a slightly longer leaching and accumulation of water in karst recipients because of the specific underground hydrographic network.

The most famous spring at the base of the Mount Igman, from which the flow of Bosnia river is directly formed, and hence the name, has an average abundance of 5 m^3/s and maximum of 18 m^3/s. Toward the Sarajevo basin, the water of Brezovacki fault is also directed and it gives a minimum of 1, 4 m^3/s and a maximum of 25 m^3/s. Other springs have a much lower abundance, which is measured in liters per second, among which the most famous ones are: Krupac 25 l/s, Hrasnica 60 l/s, Semizov well Q = 50 l/s, Stojcevac Q = 30 l/s and others. The total amount of karst water which directly ends up into the Sarajevo basin is about 14 m^3/s, which is close to half of the flow through the flow meter in Reljevo, which amounts to 28.7 m^3/s.

Drained water from karstic corrosion surfaces of Bjelasnica and Igman are being washed down, taking with them topographic detritus regardless of whether it came from natural or anthropogenic sources. The detritus is transported with it, so the waters at the springs can change their physical and biological – chemical properties. Hydrographic direct connections through karst underground affect directly the most the quality of water in springs that form the surface hydrographic network and groundwater.

Source waters

Sarajevo basin, which with the Igman-Bjelasnica morphostructure has contact through a tectonic fracture called Busovacki fault, belongs to accumulative Miocene-Pliocene geological formation and shows a tendency of subsidence. Toward the Igman and Bjelasnica it forms quandaries to karst waters and with that it defines the depth of the aquifer. A tectonic predominance of Sarajevo basin is evident by the hydrogeological chronology, which in addition to the normal groundwater has also thermo-mineral waters, which belong to the juvenile, geologically very young waters.

In geologically young sediments of sands and gravel, waters are intruded that together with them build the source waters. Accordingly, source waters are the accumulations of water in the gravels and sands of quaternary and recent geological age, whose lower base is limited by the impermeable Miocene series which lithologically consists of mainly clay and clay conglomerates.

In its roof seam are younger Quaternary deposits of sand and gravel in which the water ascedentally balances towards the upper limit of the source water determined by the immediate level, which depends on the inflow of karst waters of Igman and Bjelasnica and direct rainfall that infiltrates in a loose series. Horizontal piezometric flow of the source water is determined by the coarseness of sand-gravel mass, inclination of the impermeable series and the pressure that is formed by the inflow karst waters from the direction of Mount Igman (Spahić, M. 2013).

Upper source water level depends on the water level of the rivers that make the surface river network in the Sarajevo basin. At the time of the floods, high water levels occur in the streams from which the river water is poured out from the riverbed, and then infiltrated into the water source and vice versa; at the time of low water levels in the riverbeds the groundwater is poured into riverbeds and it maintains them during dry periods. That is a stable water level and river flow. This is proving a direct link of surface waters and those that are contained in the wells of Sarajevo basin. The combination of changing river regime, which is the direct consequence of rainfall and water stable regime, formed from the underground karst and source waters and on the surface of Sarajevo basin a dense network of surface flows and is above the average for Bosnia and Herzegovina.

HYDROECOLOGICAL PROBLEMS IN SARAJEVO BASIN

Water protection zone

Areas where the natural water is accumulated and then taken for the purposes of water supply are appointed as the water protection zones. In this area, a special control measures, prohibitions and protection are applied from all activities that may pollute natural waters. This is where, after the conditioning, we get a drinking water**.**

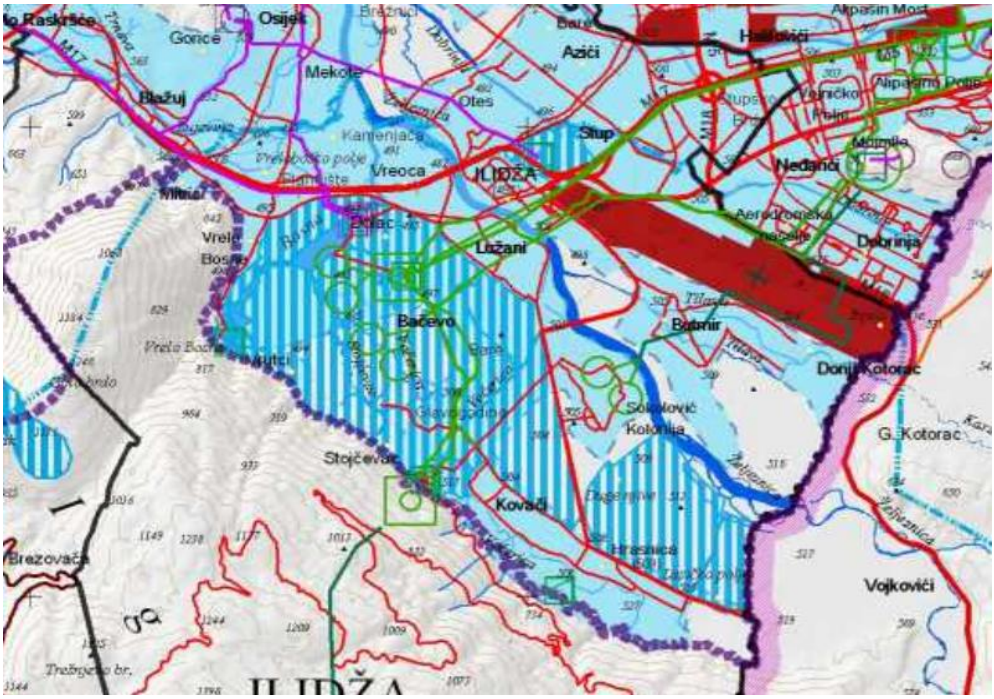

Fig. 1. Water protection zone in the Sarajevo basin shown with the vertical blue lines
Source: http://analiziraj.ba/2016/11/13/vodozastitna-zona-u-sarajevu-raj-za-investitore-i-bakterije/

According to the ‘’Regulation on the definition of the conditions for determining the sanitary protection zones and protective measures of water sources for public water supply of the population’’, (Free Newspapers of FBIH 88/12), the water protection area is defined and it indicates a narrow, fenced area around the water intake structure that in addition to the water intake includes and possible purification plant, reservoir, pump station, administrative and operating facilities, as well as other infrastructure facilities which are used for the purposes of providing of public water supply. The water protection zone in the Sarajevo basin was defined according to this provision. (Fig. 1.)

Water protection zone shown on the map (Fig. 1.) was defined in the 1987. After the end of the war, began the anthropogenic pressing, particularly the urbanization and road infrastructure, except in the immediate vicinity of the zone and in some places within it. In addition to defining the boundary of the water protection zone, some rules of the sanitary protection of drinking waters were made and are in line with similar documents in the European Union and neighboring countries (Official newspapers of FBIH 51/02).

According to the same document the water protection zones were ranked, from I to IV given in units of length (m or km) and time (days and years). Time units define external borders of the area of protection zone, to the line from which the groundwater, under the assumption of continuous extraction at the source of the maximum daily requirements of water supply system, reported by the lowest number of days, or the lowest number of years of flow to the water intake. (Fig. 2).

Vodozaštitne zone	FBiH (2002.)	FBiH (2012.)	Hrvatska	Srbija	Velika Britanija
Prva	50 m (Ia)	3-10 metara	10 metara	3-10 metara	50 dana* (min. 50m)
Druga	50 dana* (Ib)	**10 dana** *	50 dana*	50 dana*	400 dana* (min. 250m)
Treća	180 dana * (II)	**50 dana** *	5-25 godina*, ovisno od kapaciteta izvorišta	200 dana* (min. 500m)	hidrogeološka granica podzemnog sliva
Četvrta	hidrogeološka granica podzemnog sliva (III)	hidrogeološka granica podzemnog sliva			

Fig. 2. Zoning of water protection zones
Source: http://analiziraj.ba/2016/11/13/vodozastitna-zona-u-sarajevu-raj-za-investitore-i-bakterije/

In Sarajevo basin, in which are formed the source waters from which Sarajevo is supplied with, all the water protection zones could be declared the first zone, due to direct contact of source and karst-fracture waters from the hinterland of Igman and Bjelasnica. Therefore, any anthropogenic usurpation of the drainage area from which the rainwaters are

infiltrated toward the source aquifer in the Sarajevo basin has a direct impact. Waters, for example, from IV water protection zone are getting much earlier than the time, which is specified for some countries in the table. (Fig. 2). Hydrogeological characteristics of water protection zones point to this. Sarajevo water protection zone is completely different from some of the countries listed in the attached table. For example, let us mention Great Britain, which has nowhere near the same hydrogeological conditions in which the source water occurs compared to the water protection zones of Sarajevo basin where karst-fissure water dominates from its hinterland.

Water protection zone of the fourth level, which includes the karst – corrosion morphostructure of Igman and Bjalasnica and their tourist facilities such as Babin Do and others, is from recent just as important for considering antropho-pressing as are the settlements and infrastructure in the municipality of Ilidza. In this case, the time limit of water inflow to the water intake measured temporally is nearly identical to the measures of length in the lower ranked water protection zones because the underground or surface inflow is natural and continuous and therefore constantly acting in places of water intake. Thus contamination that occurs with the anthropogenic activities without built infrastructure of protection from the fourth protection zone which is defined by the temporal time of water inflow, impacts just as negatively on the water intake as negative actions on the first protection zone, which is measured by length units.

The problem of water protection zones in Bosnia and Herzegovina is in the fact of political organization other than the entity one, even the territorial cantonal networking in FBIH. In this regard, there is no unique methodology of harmonization of laws, especially when it comes to water. So cantonal authorities can make their own laws, as was done in 2010, when the Sarajevo Canton adopted its own Water Act. In addition, laws are changing rapidly and thus water protection zones too without any public debate and the lack of environmental permits. It's not about the excuse of the governing structures that that laws are changing in order to harmonize with the water protection zones with the neighboring countries or with the European Union. Such harmonization is, as already mentioned, unacceptable due to the specific of the water formation in water protection zone of Sarajevo basin.

Exploitation of water in water protection zone

Exploitation of water in Sarajevo basin is carried out at the site of Bacevo. In this area there are 29 wells and filter plant, from a total of 36 existing in the water protection zone. The wells have a depth of about 25 m, and one has a depth of about 100 m. There is a large amount of water in them, which is confirmed by data of transport through the water infrastructure in the direction of the reservoirs: Mojmilo about 1300 l/s, Alipasin bridge 750 l/s and Igman 450 l/s, which amounts of 2,5 m^3/s of water in total.

In addition to the Bacevo, for the purposes of water supply from the water protection zones, waters from localities Sokolovic and Stup are being used as well. From these sites, 20% water is provided, and from Bacevo 70 % of water of the total amount of water exploitation. The water in the water intake sites are getting there through loose series seepage, which is a natural filter before the water arrives in the filter plants. Natural filters which include gravel and sand can have unlimited use in case of waters that are very little loaded with mechanical waste. If inflow waters are contaminated with chemical or biological contaminants, natural filtering is not enough. In addition, natural filters cannot be

cleaned, except moving the location of the well, which is very demanding and expensive. Plants with wells, reservoirs, pump aggregates, hydro flex-plants and the water supply network, of length of 1064 km; make the water supply system in Sarajevo.
To this system, the drainage of usable waters and other raw sewage through the sewage system is added, whose length is 1013 km. This is the sewer system of which 473 km of faecal waste is directed toward devices for cleaning before their discharge into the river recipients of the Miljacka and Bosnia, which, from the year 1992 onward, are unfortunately not in operation. The rain sewage amounts of 335 km and 146 km is mixed sewage. The inlet and drainage infrastructure together makes a double system of water supply and sewerage.

Quality of inflow waters in the exploitation basins

The inflow of waters to water collecting zones in water protection zones of Sarajevo basin is carried out with the inflow from the karst – corrosion hinterland of Igman and Bjelasnica and the infiltration of water to the phreatic source. The quality of this water can be determined by physical, chemical and biological methods, followed by taking measures and procedures of removing the same by-products in them. In this context the quality of the water used in the water supply in Sarajevo is treated based on published data.

From the many inscriptions on the quality of water in the water intake site Bacevo it was noted that waters are being dirtied after a heavy rainfall, which clearly indicates that the infiltration from the surface is very quickly transferred to the wells from which the water for water supply is exploited. The turbidity of water is a result of the erosion and denudation of topographic surface. If the surface from many reasons is nude and covered in dust, then it is washed away by the precipitation waters and drained into the lower floors up to the well accumulations as dirty and muddy water. Turbidity represents mechanical pollution, if the same has not been in contact with other toxic substances, such as artificial fertilizers and protective preparations for plants used in agriculture. In addition, if the washing is done on the roads on which the pollutants originating from the exhaust gas and petroleum products are accumulated, then, in addition to turbidity, waters are oily as well. The turbidity of water warns of reduction of green and grassland areas in the water protection zone regardless of their rank. Increased turbidity will occur from the close water intake zone, because the deposition of particulate sediments depends on the uniform speed of sinking, turbulence of water and their flow rate. If the turbulence and flow rate of sediments is lesser, and their speed of sinking is greater, and then the water will be less blurred and vice versa.

About other hydro ecological problems in water protection zone of Sarajevo basin we learned through newsletter of the Institute of Public Health of Sarajevo Canton, which as part of its regular activities, as well as preventive health reasons performs tests of water and its quality in the rivers of Sarajevo canton. Testing the quality of river water of the Sarajevo canton is carried out with the aim of using them for swimming and recreating in the hot summer months. Based on these analyses we get the data about their pollution, based on which it is judged possible infiltration of polluted water in water intakes of water protection zones of Sarajevo basin, through which they flow.

General state of the river flows is unsatisfactory because the closest urban center of Sarajevo doesn't have complete disposal of wastewater in the sewer, as well as the fact that the city collector for waste water treatment in Butile is not operational. These findings of the

institute of Public Health of the Sarajevo Canton confirm the fact that the used waste water and sewage are discharged into the river recipients without prior treatment. (Table 1.)

Table 1: Results of microbiological, physical and chemical quality of water in the rivers of Sarajevo Canton on 13 July 2016; (P – found; NP – not found)

River	Place of sampling	Esherichia coli on 36±2 °C; 21± 3h	Entero-Coccus spp on 36±2° C; 44±4h	No. of coliform germ	Total number of living germ, 22± 1°C, 48h	Total number of living germ, 37±1°C; 48 h	Clostri-dium spp. 48 h
Miljacka	Bentbasa	P (20)	P (25)	P (20)	80	50	P (20)
Zujevina	Blazuj	P (25)	P (20)	P (20)	90	60	P (80)
Bosnia	Roman bridge	NP	P (20)	P (20)	20	140	P (30)
Zeljeznica	Ilidza	P (20)	P (15)	P (25)	20	20	P (30)
Dobrinja	Naselje	P (20)	P (20)	NP	100	150	P (45)
Moscanica	Lower Moscanica	P (15)	P (15)	P (30)	130	100	NP

Source: JU Institute of Public Health of Sarajevo Canton, no. 05.5-3386-8/16 from 20.07.2016.

Pollutions originate from sewage that flows directly to the karst – corrosion surface of Igman and Bjelasnica as well, where they directly through karst crack appear at the springs of Bosnia River. The sewage system built with facilities for the needs of the 14th Winter Olympic Games in 1984 has not been adequately maintained and in a few places the feces are getting on the surface. Given the high usurpation of natural areas in recent times past the regional plans and environmental permits, the participation of the faeces is constantly increasing. All faces that got on the surface through a system of karst fissures end up at the springs of Bosnia River. Analyses carried out by the Institute of Public Health of Sarajevo Canton warn that the springs of the Bosnia River should set the board, as mentioned before, with a warning sign that the water is not potable. Table is nowhere to be found yet, it is not known on what grounds other than the assumptions that disturbs the image of natural monument „Spring of Bosnia“, which was placed hastily and without sufficient geoecological scientific and expert basis, according to the international nomenclature of IUCN, in the third category of protection, which it certainly does not meet.

Analyses of results of microbiological parameters in water samples from the rivers of canton Sarajevo, confirm fresh fecal contamination. They show the involvement of a large number of coliform bacteria identified as Escherichia coli and Enterococcus PECIES, indicating that waters of the water flows don't have water of the proper quality with respect to microbiological indicators in which pathogenic microorganisms exist. Given this state of water the rivers of the Sarajevo canton are hygienic and epidemiological threat to the health of population. Final tests of water to the conclusion that the river waters in the Sarajevo area are contaminated, so the swimming and recreation is prohibited in them.

Diseases, to which are persons who swim in such polluted rivers exposed or persons who use these rivers for recreational purposes are originating from pathogen microorganisms that originate from waste water and sewage. The most common causes are diseases from coliform bacteria, Escherichia coli, Streptococcus faecalis, although the cause may be also the other pathogenic bacteria as well, and also viruses and parasites. The presence of these bacteria in the water is concerning because they're not affected by the reagents used to purify water before its use.

Fig 3. Derelict sewage network on Igman site Brezovaca, where a direct link through karst underground towards springs of Bosnia River is established. Clogged sewer pipe with mechanical waste (left) and manhole-sewer pipes without cover (image right).

DISCUSSION AND CONCLUSION

Water in Sarajevo basin is vadose, and is formed by the karst fracture inflow water from mountain morphostructures, primarily Igman and Bjelasnica. Besides them, vadose water is formed in the groundwater layers of intergranular Miocene and Quaternary sediments, which make quandaries to karst waters.

Their total amount is determined by water balance which is the difference of inflow vadose waters towards the water accumulation, in this case Sarajevo basin, and the runoff waters that are measured by the flow on the main river flow immediately after the aqueous accumulation. This means that assuming that all waters (surface and underground ones) flow by the one hydrographic backbone – Bosnia River, then the water meter in Reljevo is a rapper for determining the gross flow of water from Sarajevo basin. According to this criterion, from the area of Sarajevo basin, the amount of 28,7 m^3/s of water flows out in total. If this information is put in relation to the population of Sarajevo, then every inhabitant, according to world standards, has at their disposal sufficient amount of water.

According to the hydro-geological prospecting and data published by the Institute for Water Management of Sarajevo Canton, the concentration of groundwater in the area of exploitation site Baceva, there is source water in a slightly smaller amount (28.4 m^3/s) compared to the one that Bosnia River is draining. This is another indicator that confirms

the previous claim obtained on the basis of the average flow of the Bosnia River on the profile of Reljevo. Thus, in the Sarajevo area there is sufficient quantity of water for water supply. From the water intake in water protection zone, more water is being taken than necessary, because during the delivery of the water, through the water infrastructure, 70% of water is being lost. This is unnecessary consumption of water, which could be used for the purpose of fabrication of water, and to be able to fully manage this resource.

The foregoing considerations apply only to average conditions, where extremely high water levels are several times higher during the floods that last when karst and snowy storage combine with maximum spring rainfall. Extremely low water levels may occur during arid summer, where they are not regular, as much as extreme weather condition due to moderately warm and humid climate in the Sarajevo basin and subalpine and alpine climate of the continental variant are preventing the regularity of such weather conditions.
Unlike a satisfactory quantity of water in the Sarajevo basin, because of athropo-pressing and insufficient protection, waters are exposed to pollution, which reduces their quantitative values. Water protection zone in the Sarajevo basin is not defined according to the laws of hydrological, hydrogeological, geological and urboecological aspects which made its water get into a serious stage of contamination.

Therefore, those who decide on the measurements and activities of waters in water protection zones need to be informed about the fundamental elements in the field of hydrology, where belongs this paper as well, so they will refrain from making hasty decisions that would have negative far-reaching consequences. We are witnessing this autumn's decision of the Assembly of Sarajevo canton which revised the spatial plan of the municipality of Ilidza to reduce the water protection zone, although it has already been attacked by illegal urban and infrastructure construction.

The formation of waters in Sarajevo basin is very specific and different, and for some examples diametrically relative to the defined standards of length and temporal measurements that determine rang of water protection zones. Inflow of waters to the Sarajevo basin is combination of karst – fissures water from the carbonates of Igman and Bjelasnica and source intergranular waters in molasses of Sarajevo basin. In these circumstances the definition of water protection areas is unnecessary because water continuously flows in and maintains the source regime throughout the year.

All the above facts, if they are not taken into serious consideration in anthropogenic activities will have far-reaching and catastrophic consequences for the population of Sarajevo, which uses water from the Sarajevo basin in water supply. Waters are already polluted at their springs at the base of the Mount Igman, as well as surface flows that drain water of the Sarajevo basin.

To eliminate negative trends it is needed to define all the water protection areas with the first zone and expand the existing one due to the specific inflow of karst waters, which enriches the source waters in the water protection zone. Also, it is needed to urgently adopt a decision to protect existing and planned springs from which is Sarajevo supplied with water. In this regard it is necessary to urgently change existing spatial plan, so the process of conversion of natural landscapes of Bjelasnica, Igman and Treskavica into the anthropogenic ones could be stopped.

References

Cvijić, J. 1910: Studien aus Bosnien und Herzegovina und Montenegro, II Tiel karstopoljen, Wien
Cvijić J. 1899: Glacijalne i morfoloske studije o planinama Bosne i Hercegovine i Grne Gore. Glas SKA LVII. Beograd, (1-169).
Ćirić, B. 1962: Tercijarne molase u Jugoslaviji. V Savetovanje geologa FNRJ, Beograd
Jpovanović, R. & Avdagić, I. 1981: Neka pitanja o razvoju i hidrogeološkoj funkciji karsnih polja. Naš krš br. 10-11
Kanaet, T. (1962): Vrelo Bosne ili vrela Bosne, Geografski pregled, br. 6. Geografsko društvo Bosne i Hercegovine. Sarajevo
Katzer, F. 1909: Karst und Karsthydrographie Zur Kunded Balkanharbiensel, Sarajevo
Milojević B.Ž. 1937: Visoke planine u kraljevini Jugoslavije. Državna štamparija Kraljevine Jugoslavije. Beograd
Milojević, R. 1062: Evolucija tercijarnih paleodepresija i Dinarisima. V Savtovanje geologa FNRJ, Beograd
Spahić, M. 2001: Jezero na Bjelašnici. Prirodna jezera Bosne i Hercegovine (limnološka monografija. Tuzla
Spahić, M. 1999: Hidrosferni kompleks. Osnovi geoekologije. Tuzla

Authors

Muriz Spahić, doctor of geographical sciences, full professor at the Faculty of Science, University of Sarajevo, Bosnia and Herzegovina. Scientific area of research includes: physical geography and environmental protection, from which he published one monography and six university textbooks. Author of over 75 scientific articles, autor and co-author of several textbooks of geography in primary and secondary schools. Responsible researcher and participant in several scientific prestige projects. President of the Association of Geographers of Bosnia and Herzegovina, editor of the scientific journal Acta Geographica Bosniae et Herzegovinae.

Emir Temimović, doctor of geographical sciences, associate professor at the Faculty of Science, University of Sarajevo, Bosnia and Herzegovina. Editor of the scientific journal Acta geographica Bosniae et Herzegovinae; author of 20 scientific papers and two books from the scientific domain of physical geography.

Haris Jahić, doctor of geographical sciences, senior assistant at the Faculty of Science, University of Sarajevo, Bosnia and Herzegovina. Performs exercises, among other things, from Tourism and environmental protection and Methods of teaching geography.