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STUDY OF LONG-TERM WATER SUPPLY IN THE AREA OF MUNICIPALITY OF TEŠANJ, BOSNIA AND HERZEGOVINA

Abstract

This paper examines the issue of water supply in the municipality of Tešanj, which has been identified as crucial for many years due to the indispensable nature of water as a basic resource necessary for life. The available capacity of the Kraševo-Jelah-Tešanj central water supply system is 47 l/s. By calculating the daily water demand in the area, we determine a water deficit of 51.11 l/s, which needs to be addressed. The analysis and synthesis of data during the preparation of the study leads to the proposition of an artificial aquifer recharge system as a solution to the long-term water supply problem in the mentioned area.

Keywords: water supply, water demand, water deficit, artificial aquifer recharge.

СТУДИЈА ДУГОРОЧНОГ ВОДОСНАБДИЈЕВАЊА НА ПОДРУЧЈУ ОПШТИНЕ ТЕШАЊ, БОСНА И ХЕРЦЕГОВИНА

Сажетак

У овом раду анализиран је проблем водоснадбијевања општине Тешањ, који се због неизаставног сегмента воде, као основног ресурса неиопходног за живот, издваја као најзначајнији већ дужи низ година. Расположиви капацитет централног вововодног система Крашево-Јелах-Тешањ јесте 47 l/s, рачунајући дневне потребе за водом на предметном подручју, долази се до податка о дефициту воде од 51.11 l/s, које је потребно надомјестити. Анализа и синтеза података током израде студије доводи до система вјештачког прихрањивања издани, као рјешења проблема дугорочног водоснадбијевања на наведеном подручју.

Кључне ријечи: водоснадбијевање, потребе за водом, дефицит воде, вјештачко прихрањивање издани.

1. INTRODUCTION

The issue of water supply in the municipality of Tešanj has persisted for many years and remains one of the most significant challenges. The Kraševo-Jelah-Tešanj central water supply system currently operates with a total capacity of 47 l/s at minimum yield. It's important to note that the Kraševo system functions independently, and there are no current provisions for transferring water between the Kraševo and Jelah-Tešanj systems, or vice versa. Considering losses in the Central Water Supply System (CWSS), the total maximum daily water demand amounts to 98.11 l/s. Consequently, the current water deficit at the sources stnds at 51.11 l/s. This underscores the urgent need for additional water to be introduced into the system. Planning for this issue is constrained by a 30-year timeframe, with the year 2052 serving as the ultimate deadline for defining long-term water demand and devising solutions for the development of water supply systems in the Tešanj municipality area 6.[1]6.[2].

2. STUDY AREA (DESCRIPTION OF THE CURRENT SITUATION)

As part of the efforts to assess the condition of the water supply system, detailed descriptions and preliminary assessments of the transportation system, transport-distribution pipelines, surge tanks, reservoirs, and pumping stations were conducted in the research area. Comprehensive data essential for developing the hydraulic model were compiled for all these structures, accompanied by the creation of a system blueprint (refer to Figure 1).

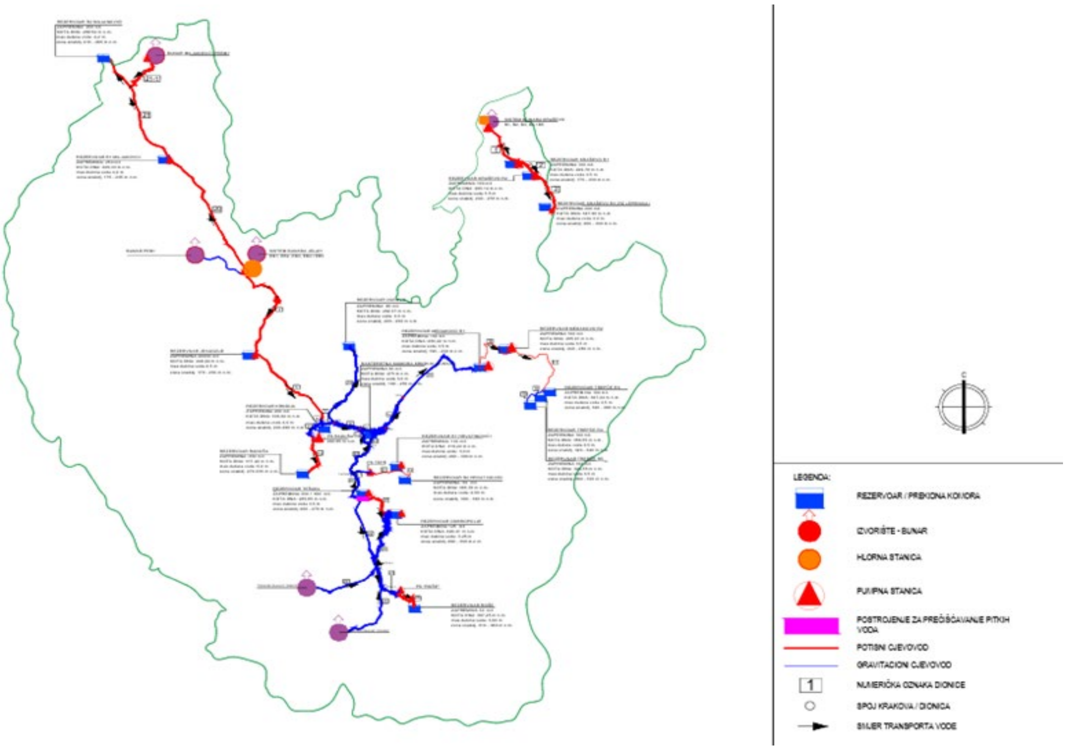

Figure 1. Overview of the Kraševo-Jelah-Tešanj central water supply system

Once the foundational infrastructure of the system was established, efforts shifted towards analyzing consumption patterns and consumer structures for each individual system. Within the entire system, special attention was given to large consumers, such as industrial entities, whose consumption was analyzed separately from that of residential areas, termed "settlement consumption." In preparing the study, consumer and supply zone data from the Geographic information system (GIS) database of Utility company "KJKP Rad"Sarajevo, were utilized. Consumption data were sourced from water meter reading reports. Water loss data were determined based on readings from the main water meters located at the entrances to the District Metered Area (DMA) zones, ensuring accurate projections 6.[3].

3. DEFINING THE PROJECTION AND CRITERIA FOR CREATING THE STUDY

As part of the process of defining projections for the study, demographic projections were initially conducted for each distribution zone within the Central Water Supply System (CWSS) as well as for local water systems. These projections were based on a thorough analysis of available data, capturing demographic trends while employing optimistic estimates.

According to estimates from 2022, the CWSS supplies water to 2,250 inhabitants through the Kraševo Water Supply System (WSS), 18,850 inhabitants through the Jelah WSS, and 5,511 inhabitants through the Tešanj WSS, totaling 26,611 inhabitants. Optimistic demographic projections anticipate that by the end of the planning period in 2052, the CWSS will supply water to 2,477 inhabitants through the Kraševo WSS, 30,138 inhabitants through the Jelah WSS, and 10,489 inhabitants, alongside 1,600 users of the Kiseljak Sports-recrestion-centar (SRC), through the Tešanj WSS. This totals 43,104 inhabitants and 1,600 users of the Kiseljak SRC.

Following the demographic analysis of the population as a consumption area, the consumption of large consumers, including industries, was analyzed. The maximum daily consumption of large consumers/industry in 2022 was 118.68 m3/day in Kraševo WSS, 1,045.00 m3/day in Jelah WSS, and 40.1 m3/day in Tešanj WSS, amounting to a total of 1,203.78 m3/day. Projecting the economic development and consequent growth in water demand, it is estimated that by 2052, 219 m3/day will be necessary for the economy in Kraševo municipality, 2,442.3 m3/day in Jelah municipality, and 60 m3/day in Tešanj municipality. Thus, by the end of the planning period, a total of 2,721.3 m3/day will be needed to supply the CWSS economy.

The maximum daily water consumption of the settlements was determined by applying consumption unevenness coefficients, which were determined based on the type of settlement for each CWSS distribution zone as well as for local water systems 6.[4].

Figure 2. Current and estimated water demand of Kraševo-Jelah-Tešanj CWSS for the planning period until 2052.

The maximum daily demand for CWSS water, accounting for losses, in 2022 is 8.99 l/s for the Kraševo system, 71.08 l/s for the Jelah system, and 18.05 l/s for the Tešanj system, totaling 98.12 l/s. By the end of the planning period, the estimated water demand with losses is projected to increase to 12.60 l/s for the Kraševo system, 149.27 l/s for the Jelah system, and 36.99 l/s for the Tešanj system 6.[5]. Consequently, the total maximum water demand with losses in the CWSS in 2052 is expected to reach 198.86 l/s. This signifies that water demand over a 30-year period is anticipated to rise by approximately 100 l/s.

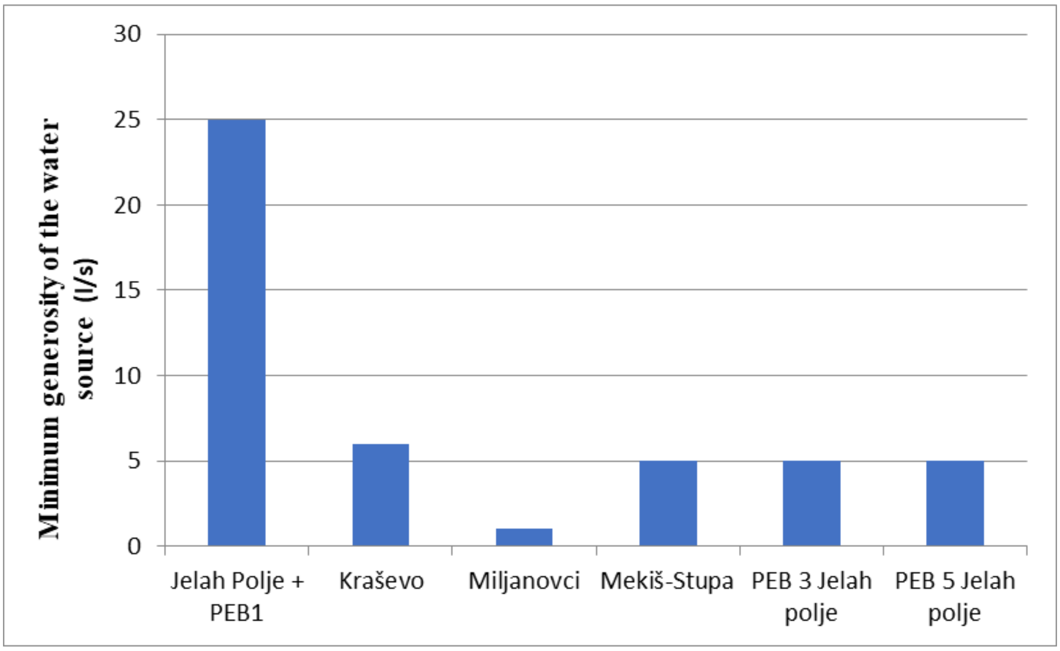

Figure 3. Current minimum yield of the water source in the Kraševo-Jelah-Tešanj sistem

4. METHODS

Based on the analysis and synthesis of data, along with previous research, the most promising location for providing additional water is the Jelah Field. Here, it's feasible to capture quantities totaling 150 l/s through artificial recharging methods. Artificial recharge involves human-induced activities where surface water is directed to infiltrate into the aquifer, leading to the accumulation of water within it. From a hydrogeological perspective, this activity results in an increase in the piezometric level within the aquifer and a subsequent rise in underground water reserves, directly contributing to an increase in the source's capacity and, potentially, an improvement in the quality of underground water 6.[6]6.[7].

Artificial recharge methods have been successfully implemented worldwide. While relatively underutilized in our region, successful applications have been observed in Niš, Požarevac, Trstenik, Sarajevo, and previously in Čačak. The primary motivations for employing artificial recharge methods stem from the following factors 6.[8]:

- compared to surface reservoirs, there are no fees for flooding the surface of the terrain, etc.
- the possibility of maintaining the piezometric level at the required height
- using the self-purifying potential of the environment during the percolation of water through the porous environment with the aim of improving water quality
- the aquifer is used as a reservoir for accumulating underground water
- the quality of underground water has advantages compared to the quality of surface water
- the possibility of pre-treatment of water and bringing the quality to the required level
- water losses are negligible compared to surface accumulations

Indeed, with artificial recharge, there's a notable increase in the general level of the water source. This elevation rise facilitates the functionality of shallower water-bearing horizons, ensuring the fulfillment of the projected capacity of the source, exemplified by the Jelah Polje source. In scenarios where there's a need to augment the source's capacity, artificial recharge enables the accumulation of the requisite water volumes. In addition, with the increase of the piezometer level at higher elevations, it is necessary to invest less electricity to overcome the additional lifting height of the well pumps 6.[9].

By employing artificial recharge, there's a reduction in the volume of subsequent water treatment required. This is because the natural filtration and purification processes that occur as water percolates through the aquifer result in improved water quality. Therefore, not only does artificial recharge serve to increase water availability, but it also contributes to enhancing the quality of water resources, leading to potential cost savings and efficiency improvements in water treatment processes downstream 6.[8].

There are several methods of artificial infiltration, categorized primarily into direct and indirect methods. Among these divisions, one notable categorization includes direct surface and direct underground infiltration methods, as well as a combined approach. For the Jelah Field and Kraševo sources, it's recommended to employ the direct surface method, considering the geological and hydrogeological characteristics of the terrain 6.[6]6.[7]6.[8].

In addition to the flooding method, other viable options include furrows and trenches, which are likely to have lesser impacts. However, the method of infiltration basins is particularly recommended. This method is widely used for artificial recharge and consists of three main components: the input side, the transport part, and the output side.

On the input side, elements are deployed to ensure that water of the required quality enters the aquifer. The transport part involves the filtration process as water infiltrates towards the water intake structure. Finally, the output side comprises the water intake structures and potentially includes treatment processes for affected groundwater.

Specifically, the entire system at the Jelah Field source would encompass:

- Surface water intake from the Usora River 6.[10]
- Raw water pumping stations
- Water pre-treatment plants
- Low-pressure pumping stations and pipelines for water transport
- Infiltration facilities
- Underground water catchment structures (tube wells combined with drains)
- Tension system for the collection and transport of captured water
- System for the treatment of captured water if necessary (chlorination)

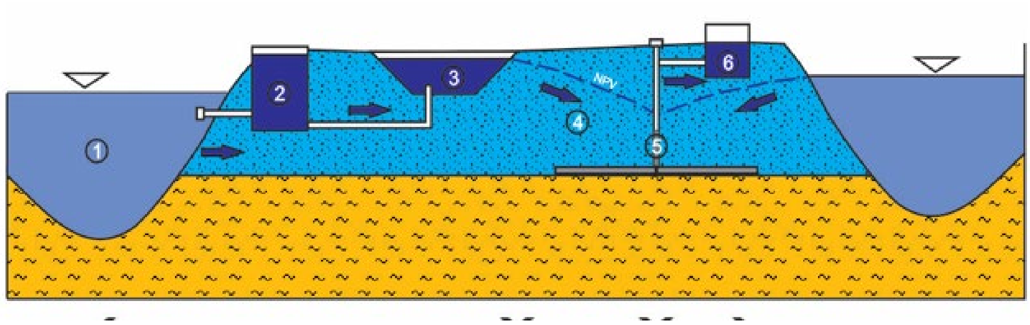

Figure 4. Schematic representation of the elements of the artificial recharge system at the source of Jelah Field (1- water intake of surface water, 2- pretreatment of water, 3- infiltration structure, 4- filtration through a porous medium, 5- source of underground water (wells and drains), 6- treatment of captured water)6.[8]

5. RESULTS AND DISCUSSION

The application of the artificial recharge method issued to the subject Tešanj municipality water supply system implies the following steps:

- Capture and treatment of minimal amounts of water from the existing springs: Jelah Field+ Exploaratory well "PEB1", Kraševo, Miljanovci, Mekiš-Stupa and new wells "PEB3" and "PEB5" (total 47 l/s).
- Capture and treatment of additional quantities of water (total required additional quantities for CWSS, for the end of the planning period, approx. 150 l/s) at the Jelah Field site and further transport with quantities from the existing wells of Jelah Field towards reservoirs and distribution of water according to the same concept that is currently established for the distribution zones of the Jelah system. For the distribution zones of the Jelah system, additional approx. 108 l/s. The increase in the capacity of the transport and main transport-distribution, gravity and pressure pipelines/pumping stations of the Jelah system is defined according to the hydraulic model of the system and the maximum daily needs with losses for the end of the planning period 6.[11].
- Connecting the Jelah and Tešanj systems, by supplying the Tešanj reservoir (289.35 m above sea level) with quantities of water from the existing and planned catchment structures of Jelah Field. The necessary quantities of water for the distribution zones of the Jelah

system (except Miljanovci) as well as the necessary additional quantities of water would be transported by a pressure transport line from Jelah Field to the Jevadzija reservoir, and then by a re-pressure transport line from Jevadzija Reservoir to Krndija Reservoir (ground elevation 304.62 m above sea level) for the Tešanj system. From Krndija Reservoir, the transport and distribution of water for the distribution zones of the Jelah system and the transport of additional quantities of water for the Tešanj system to Tešanj Reservoir would be carried out by gravity (construction of a new transport pipeline). Additional amounts of water for the Tešanj system amount to approx. 32 l/s. The height difference at the minimum water level in Krndija Reservoir and at the inlet in Tešanj Reservoir is approx. 15 m. The increase in the capacity of the transport and main transport-distribution, gravity and pressure pipelines/pumping stations of the Tešanj system is defined according to the hydraulic model of the system and the maximum daily needs with losses for the end of the planning period 6.[9].

- By connecting the Jelah system with the Kraševo system in such a way that additional approx. 6 l/s for the Kraševo system (Kraševo Reservoir 1 (R1) zone) was transported from the planned catchment structures of Jelah Field to the Krndija reservoir and then to the Krndija interruption chamber (Bukva). Considering that with the minimum yield of the Kraševo source of 6 l/s, it is possible to provide an orderly water supply to the distribution zones Kraševo R2 and Kraševo R3 (1.81 + 4.66 = 6.47 l/s) until the end of the planning period, additional amount of water from the Jelah field catchment structures could be provided by supplying the Kraševo R1 zone from interruption chamber Bukva 6.[12].
- The increase in the capacity of the transport and main transport-distribution, gravity and pressure pipelines/pumping stations of the Kraševo system is defined according to the hydraulic model of the system and the maximum daily needs with losses for the end of the planning period 6.[13].

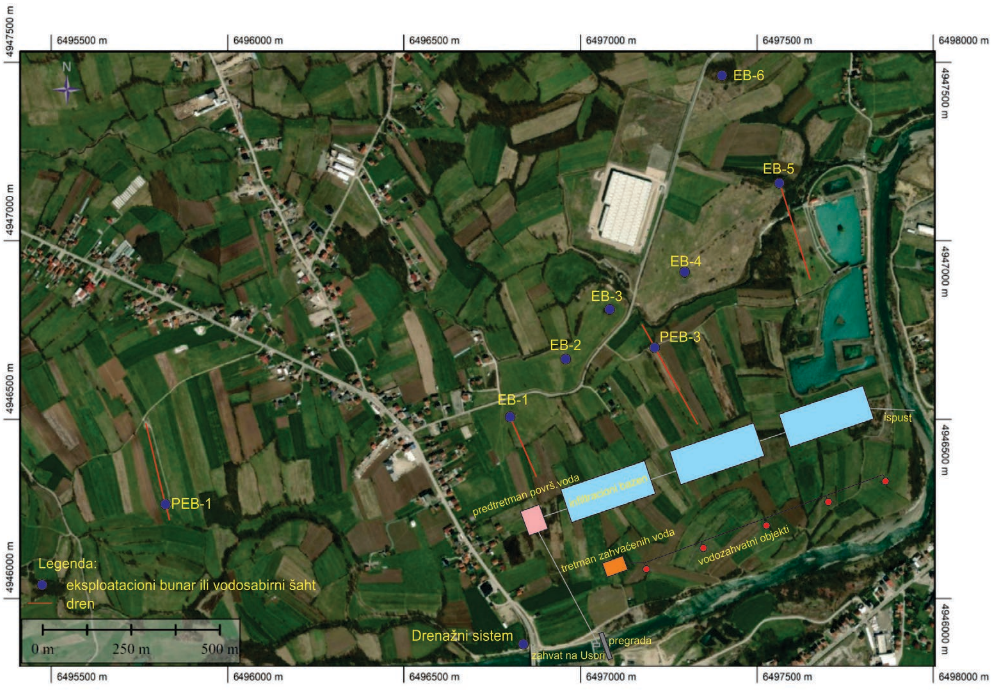

Figure 5. Presentation of the artificial recharge system at the Jelah Field source

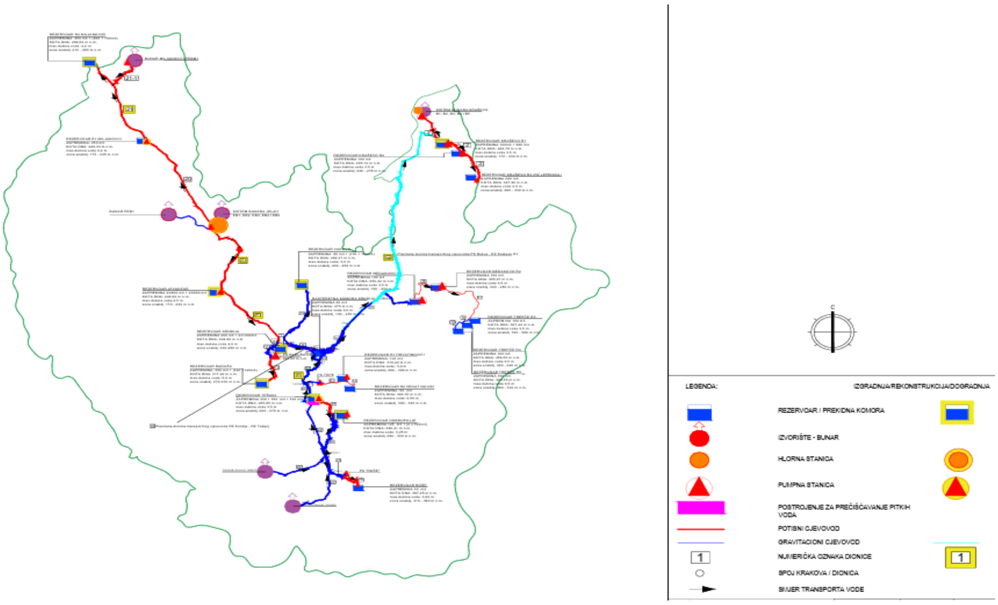

Figure 6. Planned development of the Kraševo-Jelah-Tešanj central water supply system

6. CONCLUSION

Observing the general state of the water supply system in Bosnia and Herzegovina reveals a pressing issue: an increasing number of cities and municipalities are grappling with insufficient water quantities or inadequately developed water supply systems. Insufficient investments in development and inadequate system management contribute to uncontrolled water consumption and capacity deficits. When compared with the global issue of water scarcity, particularly in terms of drinking water, it becomes evident that raising awareness about water usage is crucial in our region. Developing more centralized, extensive, and modern water supply systems is imperative, given Bosnia and Herzegovina's abundant water resources.

Many existing systems suffer from significant network losses, posing a unique challenge, especially considering that only 3% of Earth's total liquid mass is fresh water. Preserving both the quantity and quality of the natural water resources in our region is essential. Tešanj municipality faces the challenge of an insufficiently developed water supply system. Over the next 30 years, additional water quantities and system expansion and reconstruction are necessary.

Analyzing demographic trends, economic and industrial development, it's evident that there's a deficit of 100 l/s in the maximum daily water demand category for the Tešanj municipality CWSS. Among various methods to provide additional water, the study identifies water supply from the Jelah Field as a viable option. Utilizing the method of artificial recharge, up to 150 l/s can be obtained from this area. Among the types of artificial recharge, direct surface recharge of the river is deemed the most applicable for the identified source.

It's crucial to emphasize that alongside exploring new water sources, efforts must also focus on network reconstruction and expansion, particularly in areas prone to large losses and those posing health risks due to outdated materials. By addressing these issues comprehensively, we can ensure a sustainable and reliable water supply system for the future.

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