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NATURAL AND ANTHROPOGENIC FACTORS INFLUENCING THE VELIKA MORAVA RIVER WATER REGIME

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Abstract: *The Velika Morava represents the largest river basin in the Republic of Serbia, with a total area of 37,444 km², of which 36,163 km² belongs to Serbia, accounting for 42.38 % of its total territory. In its lower course, it is a typical lowland river that frequently changes the geometry of its riverbed under the influence of natural and anthropogenic factors, which poses a major problem for the establishment of river navigation. River navigation on this river was established at the beginning of the 19th century, when the first steamboat arrived in Stalać, and during that period it was used exclusively for tourism purposes. Today, only the last 15 km of its course are navigable for the vessels of the River Flotilla in the execution of assigned tasks. However, the river flow itself and its hydraulic connection with groundwater formed in the alluvium of this river are of exceptional importance for the water supply of the population and industry, for agricultural purposes (irrigation), as well as for the extraction of sand and gravel from the riverbanks and the riverbed itself. The paper will present an analysis of natural and anthropogenic factors using statistical methods, as well as an assessment of their impact on the geometry of the river course, the regime of surface and groundwater, and, in this regard, the utilization of this natural resource for various purposes.*

Keywords: *water regime, river navigation, water supply, sand and gravel exploitation, Velika Morava*

1. INTRODUCTION

From the very beginning to the present day, human civilization and settlements have been tied to riverbanks and river courses themselves. The river was their source of everything needed for survival. Rivers provided sufficient amounts of water for water supply, irrigation of crops, and livestock watering. They also served as routes for river transport, sources of high-quality food (fishing), renewable sources of building materials (clay, gravel, and sand), and the like. However, it was also necessary to defend against rivers. This was particularly crucial during high water levels and the onset of flood waves. For this reason, historical records were initially kept indicating which areas the river flooded (the inundation area). Buildings were relocated and constructed beyond the influence of recorded flood waves, while digging wells in areas with settlements allowed the population to have accessible water for their own needs right where their living quarters were located.

Later, monitoring was established—initially for surface waters and subsequently for groundwater. One of the first instruments for tracking changes in river levels was the nilometer, used by the ancient Egyptians to monitor the Nile River. Much later, official services and institutions began to form. They established observation networks and conducted observations and measurements, initially of quantitative parameters (water levels and discharges) and later of qualitative parameters when that became necessary. By establishing a sufficiently long observation

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series of a quantitative parameter, it became possible to discern changes in their regimes resulting from both natural factors (climate change) and anthropogenic factors (dam construction and the formation of surface reservoirs, gravel and sand extraction, riverbed relocation for infrastructure projects like roads, or for expanding the extraction areas of existing or new mines, etc.). Many authors have analyzed the impact of natural and anthropogenic factors on changes in surface water regimes in their papers. For example, Wrzesiński & Sobkowiak [1] conducted a detailed analysis of the impact of natural and anthropogenic factors on changes in the water regime of the Vistula River (Poland), aiming to establish better water resource management and hydrological forecasting. A group of Ethiopian co-authors [2] addressed a similar topic, using the regime of the Gumara River (Ethiopia) as an example. Rempel & Church [3], focusing on the Fraser River (Canada), presented the impact of anthropogenic factors (gravel extraction) on the river course itself, as well as its overall environmental impact.

Since the banks and beds of larger rivers contain significant (mostly renewable) reserves of sand and gravel, extraction fields used for harvesting these building materials are often located on their banks. This paper presents how illegal and uncontrolled sand and gravel extraction from the banks of the Velika Morava River near the Ljubičevo Bridge affected the water resource of the Velika Morava itself, as well as the groundwater within the river's alluvium. During the 1990s, in the section near the Ljubičevo Bridge, this extraction led to the deepening of the Velika Morava riverbed by about 4 m, which reduced groundwater reserves in this area and degraded their quality. As a consequence, due to increased nitrate concentrations in the groundwater, the "Ključ" water source had to be disconnected from Požarevac's water supply system in 2006 [4], while the Trnovče water source (supplying Velika Plana and Smederevska Palanka) operates at a reduced extraction capacity [5].

In terms of basin size (37,966 km²) and length of its course, the Velika Morava is one of our largest rivers. Together with the Južna and Zapadna Morava, it drains just under 50% of Serbia's territory. The maximum discharge of the Velika Morava is 2,350 m³/s, the lowest recorded discharge is 25 m³/s, while the mean annual discharge stands at 257 m³/s [5]. This is a typical lowland river, featuring numerous meanders, oxbow lakes, and abandoned channels. From an agricultural production perspective, the alluvial plain of the Velika Morava represents high-quality soil suitable for cultivating grains, vegetables, industrial crops, and more. This has also influenced population density, though settlements are mostly located along the edges and less frequently on the alluvial plain itself.

On the other hand, river deposits of sand and gravel in the Velika Morava alluvium are among the most important construction materials and carry the character and significance of a natural resource. In addition to illegal gravel and sand extraction from the riverbed itself or its banks, it is a frequent occurrence for agricultural land to be purchased from owners, after which extraction begins on that very plot. The topsoil is mostly sold as high-quality earth, while the deeper layers are excavated for gravel and sand. This extraction has a major negative impact on neighboring agricultural lands, which are also quickly abandoned as extraction progresses, ultimately falling into the hands of those involved in gravel and sand extraction. This results in the permanent devastation of prime agricultural land [5].

Regarding navigability and river traffic, the Velika Morava was navigable along almost its entire length in the 19th century, from its confluence with the Danube to Stalać (the steamboat "Morava" sailed to Ćuprija and Stalać in 1867) [6]. Today, the Velika Morava is not navigable due to the dimensions of the waterway—primarily the depth, which has changed compared to the 19th century. This is the result of intensive erosion along its constituent rivers and main tributaries, primarily the Južna Morava, as well as the deposition of the mobilized material in the downstream sections of the Velika Morava. The aforementioned gravel and sand extraction, which led to the 4 m deepening of the riverbed downstream near the Ljubičevo Bridge, also caused an increase in the hydraulic gradient of the water table. Increased gradients drive more pronounced headward (regressive) erosion in certain upstream sections of the Velika Morava, causing further riverbed deepening upstream. Consequently, the Velika Morava is navigable for naval fleet vessels for only 15 km upstream from its confluence into the Danube River, as established by the Decree on International and Interstate Waterways [7].

2. METHODOLOGY

For the purpose of researching the impact of natural and anthropogenic factors (gravel and sand extraction from the banks and the riverbed itself) on the regime of surface and groundwater, all historical data on the water table elevations of the Velika Morava River at the Ljubičevo Bridge profile were collected, covering the period since monitoring was established (1923). Additionally, data on groundwater levels observed in piezometers placed perpendicular to the Velika Morava riverbed were gathered. Monitoring of the Velika Morava water levels was conducted daily (from 1923 to 1960 using a staff gauge, and from 1960 to the present day using a water level recorder/limnigraph). The groundwater regime is monitored using water level meters every 5 or 10 days. Groundwater monitoring in this section was established in 1977 and 1978. Subsequently, in 1987 and 1988, the existing network of observation facilities (piezometers) was densified, while during 2002, automatic water level loggers were installed for continuous groundwater monitoring. Figures 1 and 2 present comparative diagrams of the absolute water level elevations of the Velika Morava at the Ljubičevo Bridge gauging station and the groundwater level elevations recorded in the accompanying piezometers, covering the observation period from 1977 to 2018 (the period from the inception of groundwater monitoring up to 2018). Figure 1 refers to the right bank, and Figure 2 to the left bank [8].

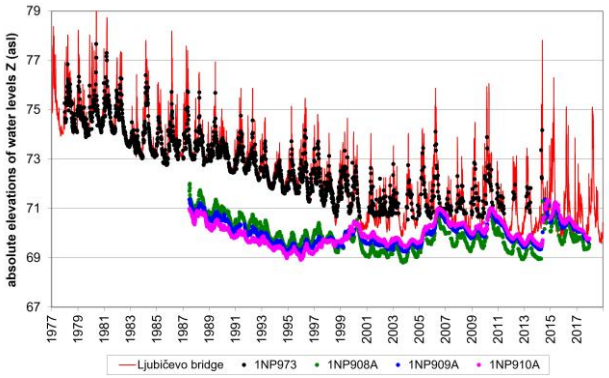


Figure 1. Comparative diagrams of the absolute water level elevations of the Velika Morava at the Ljubičevo Bridge gauging station and the groundwater levels observed in piezometers, observation period from 1977 to 2018 (right bank) [8]

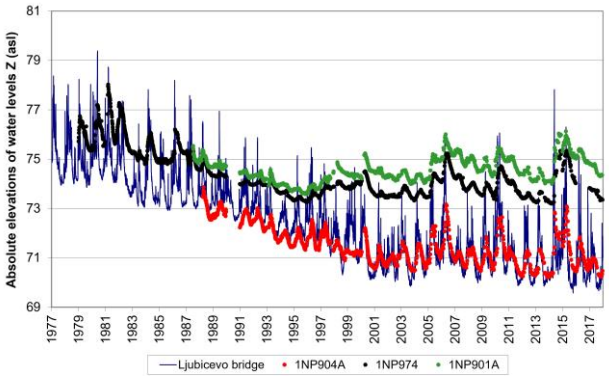


Figure 2. Comparative diagrams of the absolute water level elevations of the Velika Morava at the Ljubičevo Bridge gauging station and the groundwater levels observed in piezometers, observation period from 1977 to 2018 (left bank) [8]

It is clearly visible from diagrams 1 and 2 that the deepening of the Velika Morava riverbed affected both the water table elevations of the Morava and the groundwater levels. What is clearly evident from both Figure 1 and Figure 2 is that in piezometers 1NP973 and 1NP904A, which are located at the shortest distances from the Velika Morava riverbed itself, during the period from 1977 to 2000, the groundwater elevations were generally hypsometrically lower throughout the entire year; meaning that during this period, groundwater recharge occurred at the expense of the Velika Morava waters. After 2000, it is clearly visible that during low water levels, as well as during medium water levels, the groundwater elevations are at a higher elevation than the water levels of the Velika Morava. In other words, a change in the direction of groundwater flow occurred, so during these periods, the river is recharged at the expense of the groundwater.

To determine whether the aforementioned deepening of the riverbed affected the homogeneity of the water level series, homogeneity tests were applied. These tests showed that the examined samples extracted for the considered periods (before the riverbed deepening - the period before 1990, and after - the period after 1990) of the Velika Morava River level elevations observed at the Ljubičevo Bridge profile do not belong to the same population. More precisely, the extracted series are not homogeneous [9].

For the purpose of determining the homogeneity of the total discharge series, Student's t-test was also utilized, in which the criterion for evaluating the mean values is obtained using the following expression [10]:

$$t = \sqrt{\frac{n_1 \cdot n_2 \cdot (n_1 + n_2 - 2)}{n_1 + n_2}} \cdot \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{n_1 \cdot \sigma_{X_1}^2 + n_2 \cdot \sigma_{X_2}^2}} \quad (1)$$

where: n_1 and n_2 are the sample sizes of time series 1 and 2, $\overline{X}_1$ and $\overline{X}_2$ are the mean values of time series 1 and 2, σ_{X_1} and σ_{X_2} are the standard deviations of time series 1 and 2.

The variable t follows a Student's distribution with $n_1 + n_2 - 2$ degrees of freedom. In this regard, the null hypothesis is accepted—meaning the series is homogeneous—if:

$$t_{\frac{\alpha}{2}} < t < t_{1-\frac{\alpha}{2}} \quad (2)$$

where α is the significance level, and in this specific case, a value of $\alpha = 0.05$ was chosen.

Furthermore, the paper places an emphasis on separating direct runoff and baseflow, with the aim of determining whether a change has occurred in any of the components of total runoff.

Baseflow is formed at the expense of groundwater located within the basin. The intensity of groundwater recharge decreases over time depending on the basin characteristics, geological composition of the terrain, and hydrogeological conditions—namely, the types of aquifers. This is of great importance because the terrain's capacity to retain water that has fallen on the basin underground, and subsequently return it to the river course, represents one of the more crucial basin characteristics, which largely defines the runoff regime during dry periods. Rivers whose basins are primarily composed of fractured aquifers or provisionally arid terrains frequently dry up during prolonged dry periods. Therefore, during these periods, the aquifer exhausts all of its dynamic reserves on recharging the surface course. After that, the river channel remains dry because the aquifer runs out of dynamic reserves. Consequently, during low and mostly medium water levels, the water in the riverbed is sustained by groundwater.

Since the observed (total) discharge consists of direct runoff—which is a consequence of precipitation—and baseflow—which is formed through the recharge of the surface course by groundwater—this paper first performed the separation of direct runoff from baseflow. For this purpose, the BFI+ software [11] was applied, utilizing the Local Minimum method [12]. This method identifies days with the lowest flow within a defined time interval—half of the observed period minus one day before and after the analyzed day. If the flow on that day

is the lowest, it is designated as a local minimum and connected to neighboring minima using straight lines. The baseflow between these points is estimated via linear interpolation, thereby connecting the lowest values on the hydrograph into a simplified curve [13].

After calculating the direct runoff and baseflow and applying the homogeneity test to the formed series, the Baseflow Index (BFI) was also calculated. This index represents a quantitative indicator of the share of baseflow in the total river discharge at a specific profile. Essentially, the BFI represents the ratio between the volume of baseflow, V_B and the total volume of discharged water, V_T :

$$BFI = \frac{V_B}{V_{uk}} \tag{3}$$

where:

$$V_T = \overline{Q} \cdot T \tag{4}$$

and where $\overline{Q}$ represents the mean multi-year discharge, while T represents a one-year period expressed in seconds.

Depending on the geological composition of the terrain, namely the capacity of the subsurface to accumulate and release water, the BFI value varies within very wide limits, ranging from 0.15 to 0.90 [10].

3. RESULTS

By applying the aforementioned methodology, baseflow and direct runoff were calculated. Figures 3 and 4 present the hydrographs of total and baseflow runoff, specifically in Figure 3 for the first 10 years of the calculated series (1948–1957) and in Figure 4 for the last 10 years of the observation series (2009–2018). The hydrograph characterizing the entire observation period is not shown in the figure due to the length of the considered timeframe.

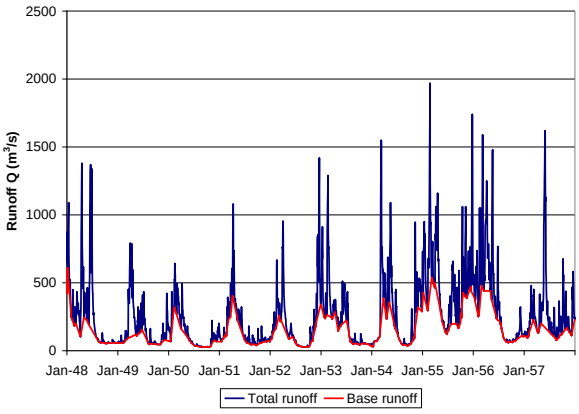


Figure 3. Hydrograph of total and baseflow runoff of the Velika Morava, Ljubičevo Bridge gauging station, period 1948–1957

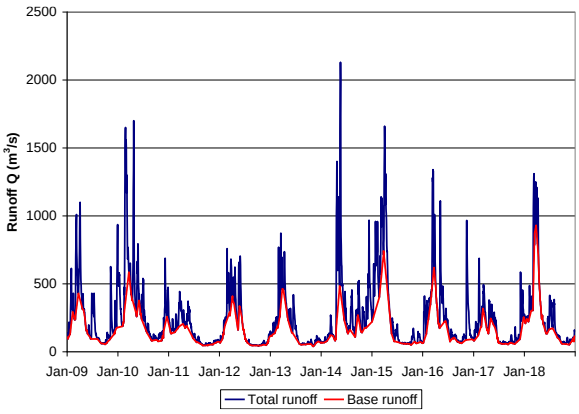


Figure 4. Hydrograph of total and baseflow (runoff) of the Velika Morava, Ljubičevo Bridge gauging station, period 2009–2018

After calculating the baseflow and direct runoff, and with the aim of applying the homogeneity test to the obtained series (total, direct, and baseflow runoff), Table 1 presents the statistics (mean value and standard deviation) for the separated periods (the first period 1948–1989 and the second period 1990–2018). Table 2 presents the calculated statistics as well as the conditions for accepting the null hypothesis.

Table 1. Mean values and standard deviations of total, direct, and baseflow runoff (m³/s)

	Q_t		Q_b		Q_d	
	I period	II period	I period	II period	I period	II period
Q_{av}	244.7	221.1	158.4	153.8	86.28	67.32
σ	70.511	72.813	43.056	45.940	35.738	32.186

Table 2. Calculated t-statistics and conditions for accepting the null hypothesis, i.e., the hypothesis that the series are homogeneous

	t	$t_{\alpha/2}$	$t_{1-\alpha/2}$	homogeneity
Q_t	1.346	-2.00	2.00	yes
Q_b	0.425	-2.00	2.00	yes
Q_d	2.254	-2.00	2.00	no

Based on the obtained values and t-statistics, it can be concluded that the 4 m deepening of the Velika Morava riverbed did not have a statistically significant impact on the change in total and baseflow runoff, while a certain change appeared in the direct runoff. In addition to the anthropogenic impact, climate change—specifically the increasing frequency of intense precipitation or its absence—certainly had a certain influence on such a result.

Furthermore, based on the obtained baseflow values, the base flow index (BFI) was calculated using equation (3). Figure 5 presents the diagram of the BFI change over time. The same diagram also displays the trend line, as well as the mean BFI values for the period before 1990 and after 1990.

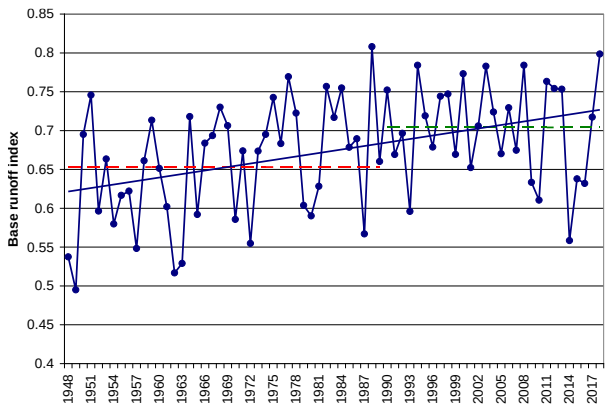


Figure 5. Diagram of the base flow (runoff) index change in the period from 1948 to 2018, featuring the trend line and multi-year mean values calculated for the separated periods (before and after 1990)

4. DISCUSION WITH CONCLUSION

Based on Diagram 5, it can be concluded that, on average, the base flow index values in the period from 1948 to 1989 are 0.05 lower than those characteristic of the period from 1990 to 2018. The BFI trend is positive, and its multi-year mean value for the period before 1990 is 0.653, while for the period from 1990 to 2018, it stands at 0.704. The lowest BFI values are associated with exceptionally rainy years, when direct runoff, formed as a result of intense precipitation, plays a more significant role in the Velika Morava riverbed. In contrast to rainy years, the BFI reaches its highest values during dry periods. In the first period, the absolute minimum BFI was calculated for the year 1949, amounting to 0.495, while the absolute maximum was recorded in 1988, reaching 0.808. During the period after 1990, an absolute minimum BFI of 0.558 was obtained for 2014—the year when record-breaking May rainfall caused by Cyclone Tamara led to severe flooding in western and central Serbia. The absolute maximum (BFI = 0.798) was recorded in 2018.

Based on the presented data, it can be concluded that there has been an increase in the proportion of groundwater forming the total runoff of the Velika Morava. This is certainly partly a consequence of the change in the direction of groundwater flow during low and medium water periods; meaning that for most of the year now, the first aquifer discharges to recharge the Morava River. The surface watercourse recharges the aquifer only during high water periods.

The lowering of the Morava River level due to the deepening of its riverbed (as previously discussed) consequently led to a drop in the groundwater levels of the first aquifer formed within the river's alluvium. Together with the change in the direction of groundwater flow—namely, the depletion of groundwater reserves to recharge the Morava River—these factors have driven the significant reduction in groundwater reserves currently observed. According to some calculations, based on an average groundwater level decline of about 1.5 m in the alluvial plain area of the Velika Morava (within the section belonging to the sheet of the Basic Hydrogeological Map of Požarevac, 1:100,000, and relative to the 1975–1985 period), the calculated volume of "lost" groundwater amounts to approximately 150.5 x 10^6 m³ (16.5%), out of the total estimated permanent reserves of 756 x 10^6 m³ of water [14]. As a result of diminished groundwater reserves, their quality degraded. Specifically, due to the use of artificial and natural fertilizers (manure), combined with the reduced groundwater reserves, nitrate concentrations exceeded the maximum allowable limit of 50 mg/dm³ after the 1990s. For this reason, for example, the "Ključ" water source, whose waters are used for the water supply of Požarevac, was taken out of service in 2006. The problem in this area was resolved by constructing infiltration basins, which helped lower the concentration of nitrate ions in the water source zone. Thus, in addition to reducing groundwater quantities, the deepening of the Velika Morava riverbed near the Ljubičevo Bridge consequently impacted the quality of these waters as well.

In addition to the aforementioned issues, there is also the problem of intense riverbed clogging (clogging/clogging of the riverbed) in certain sections, caused by an increased content of suspended material resulting from sand and gravel extraction. The result of riverbed clogging is a lowering of the water level in the alluvial aquifer due to a reduction in the contact area between the aquifer and the riverbed. This directly results in a decrease in the volume of water that infiltrates into the subsurface to be used for public water supply. The ultimate outcome is, once again, reduced groundwater reserves in this area.

Because of this, in the area of the "Trnovče" regional water source, whose waters are used for the water supply of Velika Plana and Smederevska Palanka, highly yield-abundant groundwater localities are not located in the immediate vicinity of the riverbed, but rather in the zone of a fossil river channel (meander) that has remained in direct hydraulic connection with the Velika Morava River. Thus, at a distance of about 100 m from the riverbank, vertical water intakes can capture maximum groundwater quantities of only Q = 3–6 l/s, whereas moving deeper toward the hinterland, wells of the same type can yield quantities of Q = 10–25 l/s [15].

The lowering of groundwater levels has caused many shallow dug wells, whose waters were used for irrigating agricultural crops, to run dry during arid periods (when irrigation is most necessary). Consequently, problems with irrigating agricultural areas have also emerged.

Another highly critical impact is on the navigability of the river itself. The natural course of the Morava River in its lower section is meandering in character; therefore, the riverbed shifts through natural processes, which in this area are now also driven by the extraction of construction materials from the banks and the riverbed itself. This extraction affects the displacement of the thalweg (the main current line), which, for example, can shift from the central section toward one of the banks where extraction is taking place, thereby accelerating bank erosion. In this manner, riverbanks collapse, the river meanders more intensely, and the bed depth changes frequently, which greatly complicates the establishment of navigability on

the Velika Morava.

However, by expanding its waterways, the Republic of Serbia could potentially realize major economic benefits, primarily by increasing the transport corridor of the cheapest and most environmentally sustainable mode of transport within its territory. Integrating the Velika Morava into the system of navigable rivers in the Republic of Serbia would certainly be a massive undertaking. Furthermore, it would be of immeasurable importance from the perspective of national defense, both regarding military threats and in the event of natural disasters. Expanding the waterway network would provide River Flotilla (RF) units with an increased scope for operational deployment, while a potential enemy advance would be hindered. From a national defense standpoint, a dense network of waterways and canals intersecting flat, easily accessible terrains impedes the operational advancement of enemy forces.

We must remain cognizant of these facts in order to change the irresponsible attitude toward water resources, and to reduce gravel extraction within the riparian zone and bed of the Velika Morava River to a reasonable level—one that will not negatively impact the development of existing water sources, all with the ultimate goal of improving public water supply in the future.

References

[1] WRYESIŃSKI,D., SOBKOWIAK,L.: *Transformation of the Flow Regime of a Large Allochthonous River in Central Europe—an Example of the Vistula River in Poland*. Water, 12, 507 (2020).

[2] ABEBE,W.B., TILAHUN,S.A., MOGES,M.S., WONDIE,A., DERSEH,M.G., NIGATU,T.A., MHIRET,D.A., STEENHUIS,T.S., CAMP,M.V., WALRAEVENS,K., McCLAIN,M.E.: *Hydrological Foundation as a Basis for a Holistic Environmental Flow Assessment of Tropical Highland Rivers in Ethiopia*. Water, 12, 547 (2020)

[3] REMPEL,L.L., CHURCH,M.: *Physical and ecological response to disturbance by gravel mining in a large alluvial river*. Can. J. Fish. Aquat. Sci., 66, 52–71 (2009)

[4] STEPANOVIĆ,M., BAJIĆ,D., POLOMČIĆ,D., AVRAMOVIĆ,A., MIJATOVIĆ,B., *Kvalitativne karakteristike podzemnih voda izvorišta „Ključ“ u Požarevcu*, XVI, Srpski hidrogeološki simpozijum sa međunarodnim učešćem, pp 495-500, Beograd (2022)

[5] POPOVIĆ,LJ., POPOVIĆ,Z., RISTIĆ VAKANJAC,V., VAKANJAC,B., MANDIĆ,M.: *Trenutno stanje i moguće posledice nekontrolisane eksploatacije šljunka po životnu sredinu i vodosnabdevanje - primer Velike Morave*, XV Srpski simpozijum o hidrogeologiji sa međunarodnim učešćem, Rudarsko-geološki fakultet, Univerzitet u Beogradu, pp. 435-440, Kopaonik, Srbija, 2016

[6] KRESOJEVIĆ,M., RISTIĆ VAKANJAC,V., TRIFKOVIĆ,D.: *Proširivanje mreže plovnih puteva Republike Srbije u funkciji odbrane zemlje*, SymOpIs 23, Tara, pp 727-732, 2023

[7] VLADA REPUBLIKE SRBIJE, *Uredba o određivanju međunarodnih i međudržavnih puteva*, Službeni glasnik Republiek Srbije (109/2016 i 68/2019), Beograd

[8] RISTIĆ VAKANJAC,V., KRESOJEVIĆ,M., POLOMČIĆ,D., VAKANJAC,B., NIKOLIĆ,J.: *Uticaj eksploatacije šljunka i peska na režim površinskih i podzemnih voda*, Časopis "Voda i sanitarna tehnika" LV(3) 15-24 (2025) (ed. Jasmina Agbaba) ISSN 0350-5049

[9] KRESOJEVIĆ,M., RISTIĆ VAKANJAC,V., TRIFKOVIĆ,D., NIKOLIĆ,J., VAKANJAC,B., POLOMČIĆ,D., BAJIĆ,D., *The effect of gravel and sand mining on groundwater and surface water regimes – a case study of the Velika Morava river, Serbia*, *Water* **2023**, *15*(14)

[10] PROHASKA,S.: *Hidrologija - I deo*. Rudarsko-geološki fakultet, Univerzitet u Beogradu, Beograd. 2004

[11] HYDRO OFFICE: *Software for hydrology, meteorology, geoscience & data science*. – Available from: https://hydrooffice.org., 2020

[12] WAHL,K.L., WAHL,T.L.: *Determining the flow of Comal Springs at New Braunfels, Texas.* – In: Proc. Texas Water ’95, component conference of the First Int. Conf. on Water Resources Engineering. San Antonio, American Society of Civil Engineers, 77–86., 1995

[13] SLOTO,R.A., CROUSE,M.Y.: *HYSEP: A computer program for streamflow hydrograph separation and analysis*. – U.S. Geological Survey, Water-Resources Investigations Report 96-4040, Pennsylvania, 46 p, 1996

[14] MARKOVIĆ,D. i dr. 2014: Tumač-a za Osnovnu hidrogeološku kartu Republike Srbije, list Požarevac 1: 100 000, Geološki zavod Srbije, Beograd (Revidovana verzija)

[15] POPOVIĆ,Lj.: *Izveštaj o izradi eksploatacionih bunara: BT-6, 8, 9, 10, 11, 12 na izvorištu "Trnovče" kod Velike Plane*, Fond: Geološki institut Srbije, Beograd, 2006