Acta Scientifica Balcanica, 2020, 1(2)

DOI: 10.7251/SKP201102059P **UDC: 556.5:628.1.033(497.6)**

Original scientific paper

ZERO STATE OF SURFACE WATER QUALITY IN THE AREA OF THE PLANNED BANJA LUKA-PRIJEDOR MOTORWAY

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Summary

The target location of the Banja Luka-Prijedor motorway alignment is situated in the western Republic of Srpska and belongs to the northern axis of development, which is the belt of the most intensive economic and social activity. Before starting the construction, it is necessary to determine the state of surface water pollution, that is to say the zero state, in order to later have a pragmatic idea of the impact of traffic on the quality of surface water during the motorway operation. The paper presents the results of surface water analysis, which will be the basis for further assessment of possible changes in quality when the highway is put into operation. In order to provide a detailed analysis of the existing surface water quality in the investigated corridor of the future motorway, the physical-chemical parameters of the Kozaračka River and the Luščica River were analyzed. The obtained results show that the water quality of these watercourses in relation to certain parameters ranges from the first to the fourth class of water quality.

Key words: motorway, water quality, zero state

INTRODUCTION

The impact of road construction on watercourses is inevitable, but it can be minimized by adequate measures (Frantzis *et al*., 1997; Knežević *et al*., 2012). In order to protect watercourses, the initial step is to determine the zero state, which will be the basis for their further monitoring in order to preserve the quality of water itself and its ecosystem (Dalmacija *et al*., 2004).

The Banja Luka-Prijedor section will represent a quality connection of the area around these cities with the existing Banja Luka-Gradiška motorway, i.e. with the Banja Luka-Doboj motorway. The concerned section will be the western part of the future transverse connection through the Republic of Srpska in the east-west direction, and which will be one of the basic road connections within the Republic of Srpska. The total length of the future motorway alignment is 40.7 km.

One of the important characteristics of the Banja Luka-Prijedor motorway location is a large number of surface watercourses with which the planned alignment will intersect

(Figure 1). These are mostly occasional torrential watercourses in which water is present only during the occurrence of heavy precipitation. The most important permanent surface watercourses are the Kozaračka River and the Luščica River. Due to the torrential nature of these watercourses and neglected and partly buried natural riverbeds, watercourses often overflow in cases of high water, which endangers material assets and damages agricultural crops of the population living in the area (Environmental impact study for the project of the Banja Luka-Novi Grad motorway construction, 2016; General project for the Banja Luka-Novi Grad motorway construction, 2016).

The key risks of building bridges and overpasses on watercourses are related to their impact on the watercourse ecosystem as well as their hydraulic characteristics through disturbance of the shape and size of riverbeds, banks, vegetation and migration of aquatic fauna (EES, 2013). Given that the area around watercourses is at high risk of torrential spills, the construction of bridges can further affect the quantity and quality of surface runoff and indirectly contribute to water retention on the surrounding land (Risley and Granato, 2014; Mallick *et al*., 2015).

Figure 1. Satellite image of the existing surface watercourses (marked with blue lines) within the scope of the corridor planned for Banja Luka-Prijedor motorway construction (marked with red line) (Environmental Impact Study for the Banja Luka-Prijedor Highway Construction Project, total length 40.7, 2021)

In order to provide a detailed analysis of the existing surface water quality in the investigated corridor of the future motorway, the physical-chemical parameters of the Kozaračka River and the Luščica River were analyzed. The purpose of sampling is to control the quality of surface waters of the Kozaračka River and the Luščica River before the commencement of works relating to the concerned motorway construction. Sampling was performed at these locations so that the impact of the works on these watercourses could be monitored later at the same locations (Pešević and Knežević, 2017; Knežević and Pešević, 2020). Determining their quality is the basis for further monitoring of possible changes due to construction as well as the use of the concerned road because polluted water from the carriageway must be purified before discharging into a recipient (Yannopoulos *et al*., 2013; Doamekpor *et al*., 2015).

In the listed watercourses, pollution originates from the discharge of sewage water and the application of certain agro-technical measures in the cultivation of agricultural land. The intensity of these impacts in the analyzed area is still negligible, so it is a significant potential of groundwater for the needs of local and regional water supply (Knežević *et al.*, 2012; Knežević and Knežević, 2015).

The planned motorway alignment intersects with watercourses in several places (Lipovac, Markovac, Trča, Duljski potok, Linjača, Ivaštanka, Trnovača, Soviljak, Bistrica, Luščica, Crpljenjača, Mamića rijeka, Nikića rijeka, Krivaja, Rajnovac, Vrijeska, Brusnica, Jaruga, Kozaračka rijeka, Repušnica, Tociluša, Gradinjača and a number of nameless watercourses as well) (Elaborate of Preliminary Environmental Impact Assessment for the project of Banja Luka-Prijedor motorway construction, 2019; Environmental impact study for the project of Banja Luka-Prijedor motorway construction with a total length of 40.7, 2021).

MATERIAL AND METHODS

For the credible determination of surface water quality in the area of the planned Banja Luka-Prijedor motorway, it was necessary to perform measurements at several locations. The accredited laboratory from Doboj performed sampling and analysis of surface waters, which provided necessary data for determining the zero state. Temperature and electrolytic conductivity were measured on the location, while other parameters were analyzed in the laboratory. The sampling included water from the Kozaračka River and the Luščica River beds in the immediate vicinity of the planned Banja Luka-Prijedor motorway alignment (Figure 2).

Coordinates of the sites (localities) taken from the Kozaračka River:

- site 1 (downstream): 44°57'35.09"N and 16°48'19.09"E.
- site 2 (upstream): 44°58'11.98"N and 16°49'44.23"E.

Coordinates of the sites (localities) taken from the Luščica River:

- site 3 (upstream): 44°55'42.13"N and 16°59'5.73"E.
- site 4 (downstream): 44°54'59.41"N and 16°58'25.02"E.

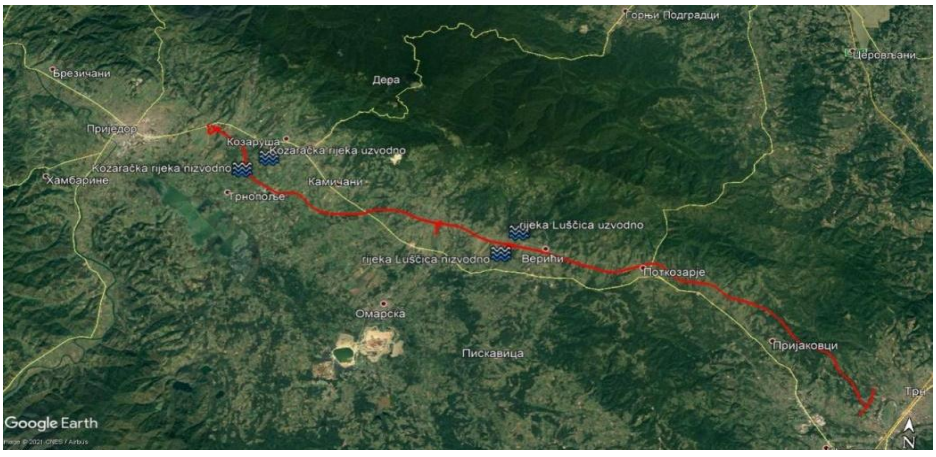

Figure 2. Locations of water sampling in relation to the planned motorway alignment (Google Earth, modified by Pešević, D., 2021)

To determine the zero state of surface water quality in the area of the future Banja Luka-Prijedor motorway, the following parameters were analyzed: temperature, pH, suspended solids, total dry residue, electrolytic conductivity, biological oxygen demand BOD5, COD, iron, cadmium, zinc, lead content and fat and oil content. The selection of parameters was in accordance with the Environmental Permit for the Banja Luka-Prijedor highway construction project. For the analysis of the mentioned parameters in accordance with the Regulation on the classification of waters and categorization of watercourses (Official Gazette of Republic of Srpska, 42/01), the methods listed in Table 1 were used.

Table 1. Parameters and test methods used to analyze surface waters

No.	Parameter	Test method
1.	Temperature	BAS DIN 38404-4:2010
2.	pH	BAS ISO 10523:2002
3.	Suspended solid substances	BAS EN 872:2006
4.	Total dry residue	BAS DIN 38409-1:2010
5.	Electrolytic conductivity	BAS EN 27888:2002
6.	Biological oxygen demand BOD5	BAS ISO 5815-2:2004
7.	Chemical oxygen demand	BAS ISO 6060:2000
8.	Iron content	BAS ISO 6332:2000
9.	Cadmium content	BAS ISO 8288:2002
10.	Zinc content	BAS ISO 8288:2002
11.	Lead content	BAS ISO 8288:2002
12.	Fat and oil content	EPA 1664-R-A:1999

Table 2 shows the limit values for individual classes of surface water quality in accordance with the Regulation (Official Gazette of the Republic of Srpska, 42/01).

Table 2. Limit values for individual surface water quality classes

No.	Parameter	Measuring unit	Limit values for quality classes of surface waters				
			I	II	III	IV	V
1.	Temperature	ºC	-	-	-	-	-
2.	pH	-	6.8−8.5	6.8−8.8	6.5-9.0	6.5−9.5	<6.5>9.5
3.	Suspended solid substances	g/m3	<2	2-5	5-10	10-15	>15
4.	Total dry residue	g/m3	<300	300-350	350-450	450-600	>600
5.	Electrolytic conductivity	µS/cm	<400	400-600	600-800	800-1500	>1500
6.	Biological oxygen demand BOD5	gO2/m3	<2	2-4	4-7	7-15	>15
7.	Chemical oxygen demand	gO2/m3	<6	6-10	10-15	15-30	>30
8.	Iron content	mg/m3	<100	100-200	200-500	500-1000	>1000
9.	Cadmium content	mg/m3	-	0.05-1	1-2	2-5	>5
10.	Zinc content	mg/m3	<100	100-200	200-300	300-500	>500
11.	Lead content	mg/m3	<0.1	0.1-0.5	0.5-2	2-5	>5
12.	Fat and oil content	g/m3	<10	10-20	20-50	50-100	>100

RESULTS AND DISCUSSION

The classification of surface waters is based on two groups of criteria: general, which define the ecological status of water, and criteria for specific hazardous and toxic substances that enter the aquatic environment as a result of various industrial and other anthropogenic activities (Official Gazette of the Republic of Srpska, 50/06, 92/09, 121/12, 74/17).

The study covered the basic groups of physical-chemical parameters of water samples. In this case, the obtained measurement results are compared with the limit values, which are defined by the mentioned Regulation (Official Gazette of the Republic of Srpska, 42/01). The results of the conducted surface water analysis of the Kozaračka River and the Luščica River are shown in the following tables.

Table 3. Measurement results at the river site Luščica River (upstream from the planned motorway alignment)

No.	Parameter	Measuring unit	Result
1.	Temperature	ºC	17.1
2.	pH	-	8.20
3.	Suspended solid substances	g/m3	8
4.	Total dry residue	g/m3	230
5.	Electrolytic conductivity	µS/cm	348
6.	Biological oxygen demand BOD5	gO2/m3	3.9
7.	Chemical oxygen demand	gO2/m3	15.3
8.	Iron content	mg/m3	89.0
9.	Cadmium content	mg/m3	<0.05
10.	Zinc content	mg/m3	< 1.0
11.	Lead content	mg/m3	< 0.1
12.	Fat and oil content	g/m3	< 2.7

Based on the analysis of the basic group of physical and chemical parameters of the quality of the river Luščica, upstream from the planned route of the highway, the following results were determined (Table 3):

- Temperature, pH, total dry residue, electrolytic conductivity, the content of iron, cadmium, zinc, lead and fat and oil content are within the limits of watercourse class I.
- BOD_5 is within the limits of watercourse class II.
- Suspended solid substances are within the limits of watercourse class III.
- COD is within the limits of watercourse class IV.

Table 4. Measurement results at the river site Luščica River (downstream from the planned motorway alignment)

No.	Parameter	Measuring unit	Result
1.	Temperature	ºC	17.1
2.	pH	-	8.20
3.	Suspended solid substances	g/m3	9
4.	Total dry residue	g/m3	238
5.	Electrolytic conductivity	µS/cm	358
6.	Biological oxygen demand BOD5	gO2/m3	5.2
7.	Chemical oxygen demand	gO2/m3	15.7
8.	Iron content	mg/m3	91.0
9.	Cadmium content	mg/m3	<0.05
10.	Zinc content	mg/m3	< 1.0
11.	Lead content	mg/m3	< 0.1
12.	Fat and oil content	g/m3	< 2.7

Based on the analysis of the basic group of physical and chemical parameters of the quality of the river Luščica, downstream from the planned route of the highway, the following results were determined (Table 4):

- Temperature, pH, total dry residue, electrolytic conductivity, the content of iron, cadmium, zinc, lead and fat and oil content are within the limits of watercourse class I.
- BOD_5 is within the limits of watercourse class III.
- Suspended solid substances are within the limits of watercourse class III.
- COD is within the limits of watercourse class IV.

Table 5. Measurement results at the river site Kozaračka River (upstream from the planned motorway alignment)

No.	Parameter	Measuring unit	Result
1.	Temperature	ºC	18
2.	pH	-	8.12
3.	Suspended solid substances	g/m3	2
4.	Total dry residue	g/m3	212
5.	Electrolytic conductivity	µS/cm	330
6.	Biological oxygen demand BOD5	gO2/m3	3.0
7.	Chemical oxygen demand	gO2/m3	10.1
8.	Iron content	mg/m3	227.0
9.	Cadmium content	mg/m3	<0.05
10.	Zinc content	mg/m3	< 1.0
11.	Lead content	mg/m3	< 0.1
12.	Fat and oil content	g/m3	< 2.7

Based on the analysis of the basic group of physical and chemical parameters of the quality of the Kozaračka River, upstream from the planned route of the highway, the following results were determined (Table 5):

- Temperature, pH, total dry residue, electrolytic conductivity, the content of cadmium, zinc, lead and fat and oil content are within the limits of watercourse class I.
- Suspended solid substances and BOD_5 is within the limits of watercourse class II.
- COD and iron content are within the limits of watercourse class III.

Table 6. Measurement results at the river site Kozaračka River (downstream from the planned motorway alignment)

No.	Parameter	Measuring unit	Result
1.	Temperature	ºC	18
2.	pH	-	8.12
3.	Suspended solid substances	g/m3	2
4.	Total dry residue	g/m3	214
5.	Electrolytic conductivity	µS/cm	337
6.	Biological oxygen demand BOD5	gO2/m3	3.1
7.	Chemical oxygen demand	gO2/m3	10.2
8.	Iron content	mg/m3	229.0
9.	Cadmium content	mg/m3	<0.05
10.	Zinc content	mg/m3	< 1.0
11.	Lead content	mg/m3	< 0.1
12.	Fat and oil content	g/m3	< 2.7

Based on the analysis of the basic group of physical and chemical parameters of the quality of the Kozaračka river, downstream from the planned route of the highway, the following results were determined (Table 6):

- Temperature, pH, total dry residue, electrolytic conductivity, the content of cadmium, zinc, lead and fat and oil content are within the limits of watercourse class I.
- Suspended solid substances and BOD_5 are within the limits of watercourse class II.
- COD and iron content are within the limits of watercourse class III.

Table 7. Analysis of the physical-chemical parameter measurement results of the Luščica River water upstream and downstream from the planned Banja Luka – Prijedor motorway alignment

No.	Parameter	Measuring unit	The Luščica River upstream					The Luščica River downstream				
			Watercourse class					Watercourse class				
			1	2	3	4	5	1	2	3	4	5
1.	Temperature	ºC	-					-				
2.	pH	-	x					x				
3.	Suspended solid substances	g/m3			x					x		
4.	Total dry residue	g/m3	x					x				
5.	Electrolytic conductivity	µS/cm	x					x				

6.	Biological oxygen demand BOD5	gO2/m3		x						x		
7.	Chemical oxygen demand	gO2/m3				x					x	
8.	Iron content	mg/m3	x					x				
9.	Cadmium content	mg/m3	x					x				
10.	Zinc content	mg/m3	x					x				
11.	Lead content	mg/m3	x					x				
12.	Fat and oil content	g/m3	x					x				

Table 8. Analysis of the physical-chemical parameter measurement results of the Kozaračka River water upstream and downstream from the planned Banja Luka – Prijedor motorway alignment

No.	**Parameter**	**Measuring unit**	**The Kozaračka River upstream**					**The Kozaračka River downstream**				
			Watercourse class					**Watercourse class**				
			1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
1.	Temperature	ºC	-					-				
2.	pH	-	x					x				
3.	Suspended solid substances	g/m3		x					x			
4.	Total dry residue	g/m3	x					x				
5.	Electrolytic conductivity	µS/cm	x					x				
6.	Biological oxygen demand BOD5	gO2/m3		x					x			
7.	Chemical oxygen demand	gO2/m3			x					x		
8.	Iron content	mg/m3			x					x		
9.	Cadmium content	mg/m3	x					x				
10.	Zinc content	mg/m3	x					x				
11.	Lead content	mg/m3	x					x				
12.	Fat and oil content	g/m3	x					x				

Water samples from the Kozaračka River and the Luščica River beds were taken at the locations closest to the planned construction sites. Based on the obtained results, the watercourses of the Kozaračka River (Table 7) and the Luščica River (Table 8) were categorized according to the analyzed parameters in accordance with the Regulation (RS Official Gazette, 42/01). The obtained results of the Kozaračka River and the Luščica River quality show that the watercourse quality in relation to certain parameters ranges from the first to the fourth class of watercourses. Still, the largest number of parameters belongs to the first class of water quality. Zero monitoring was confirmed by the Environmental Permit for the Banja Luka - Prijedor highway construction project.

During the highway construction works and its subsequent use, there may be temporary and permanent pollution of surface and groundwater. Removing the natural cover layer and creating new catchment areas, as well as pouring construction material, can lead to leaching of fine fractions under the action of precipitation and turbidity of surface water, and drainage through the soil can endanger the quality of groundwater. Turbidity of water leads to a decrease in oxygen dissolved in water, which can adversely affect the ichthyofauna of these watercourses. Construction machinery poses a potential risk of spillage or accidental spills of oil and petroleum products, motor oils and similar waste. For these reasons, it is necessary to provide protection measures when handling machine oils and train olis, and petroleum

products, while preventing any threat to water quality, as well as the surrounding flora and fauna.

After the construction of the highway and its commissioning, the emission of various environmental pollutants begins. Heavy metals (from corrosion of vehicles and road equipment), hydrocarbons (from fuels and oils), nutrients (mainly nitrogen from engine exhaust), particles (from substrate and exhaust gases), defrosting salts and other toxic substances that occur during operation highways can contaminate surface and groundwater (Folkeson *et al.*, 2009). Depending on the type of pollutant, concentration, rate of assimilation of organisms and its shape (dissolved and particles), the effects created in the aquatic environment can be acute or cumulative. The greatest risk to the aquatic environment is posed by long-lived substances accumulated in sediments and living things (heavy metals and organic micropollutants) (Winkler, 2005). Table 9 shows the average concentrations of these pollutants in highway runoff.

Table 9. Average concentrations in road runoff (average annual daily traffic >10000 vehicles/day) (Winkler, 2005)

Total solid substances	**COD**	**Total nitrogen (N)**	**Total phosphorus (P)**	**Cadmium content (Cd)**	**Copper content (Cu)**	**Lead content (Pb)**	**Zinc content (Zn)**	**Polycyclic aromatic hydrocarbons (PAH)**
mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
200	100	2	0.5	0.0015	0.1	0.03	0.5	0.003

Pollutants transported by rainwater flow into the canals along the road, and then are discharged into the surface waters over which the road passes. Taking into account the growing urban development, road runoff is becoming an increasing problem, because it is an increasingly present form of diffuse pollution. Road operators are responsible for ensuring that the construction and use of roads does not endanger the quality of natural waters (Folkeson *et al.*, 2009), or other elements of the environment.

CONCLUSION

Road construction requires significant field works, especially if the planned road is intersected by watercourses that must be bridged. The construction and exploitation of highways can have a significant impact on the quality of watercourses, but it can be minimized by adequate measures. Before the execution of any construction works, the zero (initial) water quality status of the existing watercourses was determined and should be the basis for further monitoring and determination of possible negative changes caused by the construction of the highway. The obtained results of the Kozaračka River and the Luščica River water quality show that the watercourse quality in relation to certain parameters ranges from the first to the fourth class of water quality. The quality of watercourses during construction must be controlled in order to identify possible impacts of highway construction on the quality of surface watercourses, i.e. whether construction works lead to deterioration of water quality in surface watercourses covered by the highway

REFERENCES

Dalmacija, B., Bečelić, M., Ivančev-Tumbas, I. & Teodorović, I. (2004). Voda-tipovi, legislativa i standardi. In Dalmacija, B. & Ivančev-Tumbas, I. (Eds.), *Analiza vode, kontrola kvaliteta, tumačenje rezultata* (pp. 1-36). Novi Sad: Prirodno-matematički fakultet, Departman za hemiju.

Doamekpor, L. K., Darko, R., Klake, R. K., Samlafo, V. B., Bobobee, L. H., Akpabli, C. K. & Nartey, V. K. (2015). Assessment of the contribution of road runoffs to surface water pollution in the New Juaben Municipality, Ghana. *Journal of Geoscience and Environment Protection, 4*(1), 173-190. doi:10.4236/gep.2016.41018

Elaborat o Prethodnoj procjeni uticaja na životnu sredinu za projekat izgradnje autoputa Banja Luka-Prijedor [Elaborate of Preliminary Environmental Impact Assessment for the project of Banja Luka-Prijedor motorway construction] (2019). Banja Luka: Institut za građevinarstvo „IG".

EES, Environment Effect Statements (2013). *Western Highway Duplication*, Beaufort to Ararat, Section 2, Chapter 12, Surface Water. Retrieved from: https://www.planning.vic.gov.au/__data/assets/pdf_file/0032/119777/WHDP-Section-2-EES-Ministers-Assessment_May-2013.pdf

Folkeson, L., Bækken, T., Brenčič, M., Dawson, A., Frančois, D., Kuřímská, P., Leitão, T., Ličbinský, R. & Vojtěšek, M. (2009). Sources and fate of water contaminants in roads. Sources and Fate of Water Contaminants in Roads. U: Dawson A. (Ur.) *Water in Road Structures*. Geotechnical, Geological and Earthquake Engineering, Vol 5. Springer, Dordrecht. doi:10.1007/978-1-4020-8562-8_6

Frantzis, P. C., Athanasopoulou, A. D., & Kollaros, G. A. (1997). Environmental impacts from the planning and construction of highway projects. In Marinos, Koukis, Tsiambaos & Stournaras (Eds.), *Engineering Geology and the Environment* (pp. 2687-2692), Rotterdam: Balkema. Retrieved from: https://www.researchgate.net/publication/293537667_Environmental_impacts_from_the_planning_and_construction_of_highway_projects

Generalni projekat izgradnje autoputa Banja Luka-Novi Grad [General project for the Banja Luka-Novi Grad motorway construction] (2016). Beograd: Saobraćajni institut „CIP".

Knežević, N., Cukut, S., Dunović, S. & Ivić-Rajaković, B. (2012). Očekivani uticaji na kvalitet površinskih voda tokom izgradnje i eksploatacije autoputa E661, dionica Mahovljani-Gradiška. *Put i saobraćaj*, *1*/2012, 13-16.

Knežević, D. & Knežević, N. (2015). Identifikacija uticaja izgradnje i eksploatacije autoputa Banja Luka-Doboj na vodne resurse. *Put i Saobraćaj*, *2*/2015, 27-33.

Knežević, N. & Pešević, D. (2020). Impact analysis of the Banja Luka-Doboj motorway construction on the quality of watercourses with a lower receiving capacity. *Archives for Technical Sciences, 22*(1),79-85. doi:10.7251/afts.2020.1222.0791K

Mallick, R. B., Zaumanis, M. & Frank, R. (2015). Adaptation to Flooding and Mitigating Impacts of Road Construction − a Framework to Identify Practical Steps to Counter Climate Change. *The Baltic Journal of Road and Bridge Engineering, 10*(4), 346-354. doi:10.3846/bjrbe.2015.44

Pešević, D. & Knežević, N. (2017). Impact of the construction site of a part of the Banja Luka – Doboj motorway on the quality of water in the rivers Vrbas and Crkvena. *Archives for Technical Sciences*, *17*, 99-106. doi: 10.7251/afts.2020.1222.0791K

Risley, J. C. & Granato, G. E. (2014). *Assessing potential effects of highway runoff on receiving-water quality at selected sites in Oregon with the Stochastic Empirical Loading and Dilution Model (SELDM)* (Report No. 2014-5099). Reston, VA, USA: US Geological Survey. doi: 10.3133/sir20145099

Studija uticaja na životnu sredinu za projekat izgradnje autoputa Banja Luka-Novi Grad. [Environmental impact study for the project of the Banja Luka-Novi Grad motorway construction] (2016). Beograd: Saobraćajni institut „CIP".

Studija uticaja na životnu sredinu za projekat izgradnje autoputa Banja Luka-Prijedor ukupne dužine 40,7 [Environmental impact study for the project of Banja Luka-Prijedor motorway construction with a total length of 40.7] (2021). Banja Luka: Institut za građevinarstvo „IG".

Official Gazette of Republic of Srpska, No. 42. (2001). Regulation on the classification of waters and categorization of watercourses.

Official Gazette of Republic of Srpska, No. 50 (2006). Water Law.

Official Gazette of Republic of Srpska, No. 92 (2009). Law on Amendments of Water Law.

Official Gazette of Republic of Srpska, No. 121 (2012). Law on Amendments of Water Law.

Official Gazette of Republic of Srpska, No. 74 (2017). Law on Amendments of Water Law.

Winkler, M. (2005). The characterization of highway runoff water quality. (Master' thesis). Graz: University of Graz. Retrieved from: http://lampx.tugraz.at/~portal/Files/i2150/download/Diplomarbeiten/DA_Winkler.pdf

Yannopoulos, S., Basbas, S. & Giannopoulou, I. (2013). Water bodies pollution due to highways stormwater runoff: Measures and legislative framework. *Global Nest Journal*, *15*(1), 85-92.

Received 08 November 2021.
Accepted 27 December 2021.