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Estimate Primary Impacts on the Enironment During the Construction of the Tunnel Zenica on the Corrodor Vc

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SUMMARY: During the execution of works on the construction of the tunnel Zenica, there is a certain number of activities that can cause negative consequences for the environment. In this regard, the greatest danger is represented by the technological operations of works such as: mechanical excavation, blasting, deep excavations, destruction, and removal of the natural covering layer. Also, construction machines pose a potential danger from spills or accidental spills of oil and oil derivatives, discarding of motor oils and similar waste. Uncontrolled depositing of excavated material, and a plateau for parking machinery near surface and underground water can cause negative consequences for the environment. In this paper, an assessment of the primary environmental pollutants during the excavation of the tunnel Zenica was carried out, i.e., dust and wastewater emissions during construction.

KEYWORDS: tunnel, floating particles, dust, technological water, analysis

INTRODUCTION

The aim of the environmental protection assessment is to review the existing documentation, using positive regulations and construction standards and experience in the exploitation of the project, to point out in detail the potential risks and negative impacts during the implementation of the project and to define the measures that need to be taken to prevent, remove or minimize them.

In order to see and evaluate the threat to the living environment through the impact of the construction of the tunnel Zenica, it is necessary, first of all, to perform a correct evaluation of the quality of the natural environment from the aspect of the existing state, and then, based on all the impacts that can be expected during construction, define the degree of possible impacts on certain spatial and other values of the living environment. When evaluating the impact of the construction of the Zenica tunnel on the stability and safety of the living environment, all evident impacts must be considered, in particular:

- impact on the soil,
- impact on water,
- impact on air quality (dust impact),
- impact on forest vegetation and wildlife,
- impact on the visual values of the surroundings (landscape changes-terrain),
- impact of noise on the environment.

By analyzing the impact of the construction of the tunnel Zenica on the environment, all changes must be considered, both in the case of normal plant operation and in the case of unforeseen circumstances, i.e., environmental accidents that could eventually happen.

The environmental impact assessment is made based on Article 6 of the Regulation on construction site management, mandatory documentation on the construction site and construction participants (Official Gazette of FBiH, number: 48/09, 75/09, 93/12, 99/14 and 25a/22), Regulation on the determination of interventions in space and buildings for which the Federal Ministry of Spatial Planning issues urban planning consent and/or location information (Official Gazette of FBiH, number: 34/14).

This paper deals with the primary environmental pollutants during the excavation of the tunnel Zenica, i.e., emissions of dust and wastewater during construction.

DESCRIPTION OF THE TECHNICAL SOLUTION

The two-tube two-lane road tunnel "Zenica" is located as part of the motorway on corridor Vc, section Northern administrative border of the municipality of Zenica (Nemila) - Zenica North, subsection Ponirak - southern exit from the Zenica tunnel. The route of subsection III starts from the southeastern side of the Ponirak settlement, where after approx. 136 m of open route it enters the tunnel "Zenica". In both tubes of the tunnel "Zenica", no stop lane was designed, because the length of the tunnel is more than 200 m'. The cross-section of one tube of the tunnel "Zenica" is two lanes 3.50 m wide plus two edge lanes 0.35 m wide. The left and right tunnel tubes are connected with ten cross passages for pedestrians, three passages for vehicles as well as three parking niches.

According to the design solution, the length of the left tunnel tube is 3,281,994 m, while the length of the right tunnel tube is 3,329,850 m.

The tunnel excavation of the left tunnel tube is planned from stationing 0+153.62 with the maximum overburden above the left tunnel tube of the tunnel "Zenica" in the amount of approx. 477,858 m. The tunnel excavation of the right tunnel tube is planned from stationing 0+155.76, while the maximum layer is approx. 477.858.

Picture 1. Geographical position of the tunnel Zenica on the route of the corridor Vc

Climatic Conditions in the Tunnel Zenica Construction Area

The study of the mode of action of meteorological-climatological factors requires familiarization with several different meteorological-climatological quantities that in a certain way significantly or to a lesser extent affect the transport and distribution of polluting pollutants that are emitted into the environment, thus directly affecting human life.

Significant impacts of meteorological factors are manifested through the influence of the following quantities:

- ☑ The influence of the thermal conditions of the atmospheric environment on the micro location and the state of the environment of an area, especially in the period of extremely high and low external air temperatures.
- ☑ The influence of air humidity, which, apart from its importance for the human body, also manifests itself as an important factor in the overall effect on the size of dust particles, soot, and other aerosols, as well as the formation of photo smog in interaction with other pollutants.
- ☑ The influence of the frequency and amount of precipitation. This especially applies to larger particles of settling dust, which, due to precipitation, settle more quickly on the ground, causing its pollution, as well as the pollution of water and watercourses.
- ☑ The influence of air currents, which according to the mode of action represents the most dominant meteorological parameter that affects air pollution, because it directly participates in the distribution of gaseous and solid pollutants further from the emission source.

Climatic conditions of the subject area are determined by the temperature and pluviometry regime, so it is necessary to define basic parameters, using climatological monitoring and detailed analysis of them. It can be said that this area is under the influence of a moderately continental climate, with smaller areas under the influence of subalpine and alpine climates. The average annual temperature in Zenica is 10.6 °C, the hottest month is July, with an average annual air temperature of 20.4 °C, the coldest month is January with an average annual temperature of 0.2 °C.

The total amount of precipitation measured in Zenica over several years is 803 mm on average during the year. The rainiest month is September when the amount of precipitation is 89.7 mm. The lowest amount of precipitation was measured in March, an average of only 48.2 mm. The area of Zenica is one of the drier areas in Bosnia and Herzegovina. The reason for this is the relief of this area, which prevents a stronger inflow of humid air masses. Calms are present a total of 59% of the time, and wind speeds are relatively low.

Air Quality at the Site of the Entrance Portal of the Tunnel Zenica

According to the measurement methodology, prescribed in the Rulebook on the manner of monitoring air quality and defining the types of pollutants, limit values and other air quality standards ("Official Gazette No. 01/12 and 50/19) when measuring airborne dust emissions, one measuring point is representative of an area of 4 x 4 km. Air quality limit

values can have different values depending on the sampling time, that is, the shorter the sampling time, the higher the numerical value of the quality limit value. The sampling length is standardized to 30 minutes, one hour, 8 hours, 24 hours or one month (depending on the type of pollutant and the sampling method used).

Limit values of air quality - GV in order to protect people, for floating dust PM10, TSP and settling dust (sedimentary dust) are given in the following table.

Table 1. Limit values of air quality - GV to protect people

Pollutin material	**Sampling period**	**Limit values**
PM10	Average annual value	40 **(µg/m^3)**
TSP	Average annual value	90 **(µg/m^3)**
Precipitable powder Total	Average annual value	200 **(mg/m^2/danu)**

The time during which a dust particle can be in the air in a floating state depends, first, on its dimensions and density.

That time, for still air, is determined by the mutual action of the force of gravity (G) and the opposing force of air resistance (F).

For spherical dust particles, the force of gravity is calculated using the equation:

$$G = \frac{1}{60} \cdot \pi \cdot d^3 \cdot (\rho - \rho_1) \cdot g$$

Where is:

d - particle diameter (cm),

ρ - particle density (g/cm^3),

ρ1- air density (g/cm^3) and

g - acceleration due to Earth's gravity (9.81 cm/s^2).

The force of air resistance for particles with a diameter of 1.5 to 70 (µm) is determined using the Stokes equation:

$$F = 0.3 \cdot \pi \cdot \eta \cdot d \cdot V_n \quad (\mu N)$$

Where is:

η- dynamic viscosity of still air (g/cm^2/s) i

Vn - settling velocity of particles (cm/s).

If the force of the heavier particle is greater than the resistance force, the particle will fall with increasing speed, obeying Newton's law, and if G=F, the particle will fall at a constant speed, obeying Stokes' law, and if it is a still air middle and when G is less than F, the dust particle will remain in a floating state obeying Brownian motion.

Compared to coarse dust, fine dust is characterized by a large specific surface area, greater oxidation, and adsorption capacity.

Results of Measurements of Suspended and Sedimentary Dust at the Entrance Portal of the Tunnel Zenica

In order to determine the air quality for the given section, an air quality test was performed (precipitable dust and floating particles). The measurement and testing were carried out by the company "ZAGREBINSPEKT" d.o.o. Mostar (Report No. 01-2-1-76-IV/20).

Measurements of total precipitable substances and floating particles were made at two locations, namely:

1. MS 1 - entrance to the construction site in the settlement of Ponirak i
2. MS 2 – plateau in front of the entrance to the Zenica tunnel.

Picture 2. Display of measurement locations of settling and floating dust particles

The following tables show the results of the measurement of floating particles and total settling dust for seven days at the location of the entrance and exit portals of the tunnel Zenica.

Table 2. Results of measurements of floating particles

Location	Mark	1 day	2 day	3 day	4 day	5 day	6 day	7 day
MS 1	PM10 (µg/m^3)	99,8	91,2	88,6	86,6	82,8	93,1	88,2
	TSP (µg/m^3)	189,5	182,9	177,5	185,6	175,8	181,3	188,5
MS 2	PM10 (µg/m^3)	92,3	91,2	88,6	89,6	92,5	91,3	89,5
	TSP (µg/m^3)	182,5	189,3	183,6	186,6	191,2	188,9	188,6

Table 3. Results of measurement of total precipitable substances

R. br.	Mark	Unit of measure	Measure value
1	Total Precipitable Matter (MS 1)	(mg/m^2/danu)	188,67
2	Total Precipitable Matter (MS 2)	(g/m^2/danu)	181,16

The Quality of Technological Water at the Entrance and Exit Portal of the Tunnel Zenica

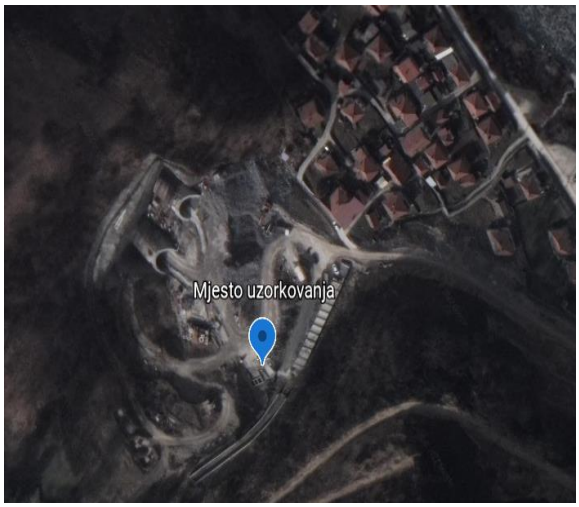
During the excavation of the tunnel Zenica, large amounts of groundwater were recorded at different locations in both tunnel tubes, which is shown in the following photos.

Picture 3. Exposure of groundwater

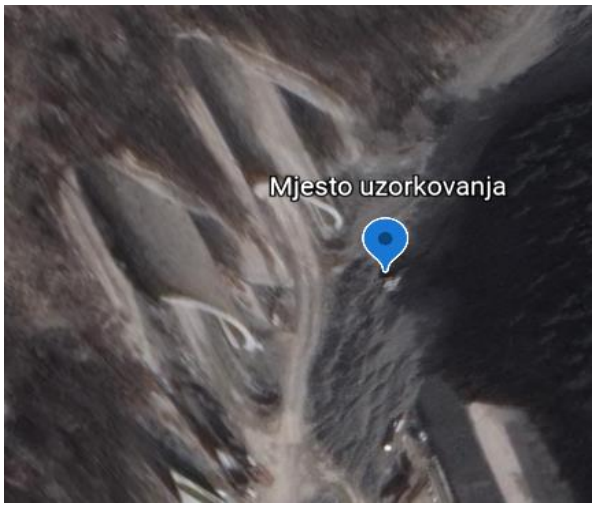
Groundwater from the point of entry into the tunnel Zenica during construction is drained through an open channel to the portal (input or output portal) where it is "passed" through a two-chamber settling tank and then drained to the natural receiver (Bosna Riverbed).

To determine the quality of technological water before discharging it into the natural receiver, a regular physico-chemical analysis of wastewater from the tunnel Zenica at the entrance and exit portal was performed by the company "ZAGREBINSPEKT" d.o.o. Mostar in accordance with the Regulation on the conditions for the discharge of wastewater into the environment and the public sewage system (Official Gazette of FBiH no. 26/20 and 96/20).

The following photos show the location of technological water sampling for physio-chemical analysis at the entrance and exit portals before discharge into the natural receiver.



Picture 4. Sampling site - entrance portal



Picture 5. Sampling site - exit portal

The following tables show the results of the physical-chemical analysis of wastewater samples from the location of the entrance and exit portal of the tunnel Zenica, which was carried out by the company "ZAGREBINSPEKT" d.o.o. Mostar (Report No. 01-2-5-V/22).

Table 4. Results of physio-chemical analysis of wastewater-entrance portal

Parametre	Measuring units	Method	Result	Threshold value	
				Public sewage	Surface water
Flow	l/s	Internal method	30	-	-
Temperature	^{0}C	Standard methods 2550 B izd. APHA-AWWA-WEF 2012.	7,9	40	30
pH	-	BAS EN ISO 10523:2013	8,5	6,5 do 9,5	6,5 do 9,0
Smell	-	RU-7.2/OV-1-31	Bez	-	-
Color	mg/l Pt	BAS EN ISO 7887:2013(C)	56	-	-
Dissolved oxygen content	mg/l	BAS EN ISO 5814:2014	8,1	-	-
Electrical conductivity	µS/cm	BAS EN 27888:2002	355	-	-
Suspended solids	mg/l	BAS ISO 11923:2002	244	<400	35
Depositing substances	mg/l	2540 F izd. APHA-AWWA-WEF, 1995	0,4	10	0,5
KPK	mgO_2/l	BAS ISO 15705:2005	<15	700	125
BPK_5	mgO_2/l	BAS ISO 5815-2:2004	2,16	250	25
Ammonia	mg/l	BAS ISO 7150-1:2002	<0,05	40	10
Nitrates – NO_3	mg/l	BAS ISO 7890-3:2002	0,56	50	10
Nitrites – NO_2	mg/l	BAS ISO 26777:2000	0,026	-	-
Total phosphorus	mg/l	BAS EN ISO 6878:2006	<0,025	5	2
Toxcity test	48EC_{50} %	BAS EN ISO 6341:2014	Nije toksična	-	>50
Oil and fat	mg/l	BAS ISO 11349:2019	11	100	20
Mineral oils	mg/l	BAS EN ISO 9377-2:2008	1,3	20	10

Table 5. Results of physio-chemical analysis of wastewater-exit portal

Parametre	Measuring units	Method	Result	Threshold value	
				Public sewage	Surface water
Flow	l/s	Internal method	30	-	-
Temperature	^{0}C	Standard methods 2550 B izd. APHA-AWWA-WEF 2012.	7,6	40	30
pH	-	BAS EN ISO 10523:2013	7,9	6,5 do 9,5	6,5 do 9,0
Smell	-	RU-7.2/OV-1-31	Bez	-	-
Color	mg/l Pt	BAS EN ISO 7887:2013(C)	59	-	-
Dissolved oxygen content	mg/l	BAS EN ISO 5814:2014	8,2	-	-
Electrical conductivity	µS/cm	BAS EN 27888:2002	467	-	-
Suspended solids	mg/l	BAS ISO 11923:2002	131	<400	35
Depositing substances	mg/l	2540 F izd. APHA-AWWA-WEF, 1995	0,3	10	0,5
KPK	mgO_2/l	BAS ISO 15705:2005	<15	700	125
BPK_5	mgO_2/l	BAS ISO 5815-2:2004	2,08	250	25
Ammonia	mg/l	BAS ISO 7150-1:2002	<0,05	40	10
Nitrates – NO_3	mg/l	BAS ISO 7890-3:2002	0,28	50	10
Nitrites – NO_2	mg/l	BAS ISO 26777:2000	0,033	-	-
Total phosphorus	mg/l	BAS EN ISO 6878:2006	<0,025	5	2
Toxcity test	48EC_{50} %	BAS EN ISO 6341:2014	Nije toksična	-	>50
Oil and fat	mg/l	BAS ISO 11349:2019	12	100	20
Mineral oils	mg/l	BAS EN ISO 9377-2:2008	1,1	20	10

CONCLUSION

The aim of the paper is to determine the impact of the works during the construction of the tunnel, (I suggest a comma after the word tunnel) Zenica on the route of corridor Vc, on air pollution as well as pollution of surface or underground water.

According to the measurement results obtained at both measurement sites (MM-1 and MM-2) for total suspended dust and PM10, and by comparing them with the limit values of air quality for average annual values, it is concluded that all measured values of the emission of suspended dust are twice higher than the limit values , while the measured values of sedimentary dust at both measuring points do not exceed the limit values prescribed by the Ordinance ("Official Gazette number: 01/12 and 50/19).

Based on the results of the physico-chemical analysis of wastewater, it can be concluded that suspended substances in both analyzed samples exceed the threshold value for discharge into surface water, while all other tested parameters meet the threshold values in accordance with the Regulation on conditions for discharge of wastewater into the environment and the public sewage system (Official Gazette of FBiH No. 26/20 and 96/20).

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