SECONDARY SCHOOL MATE BLAŽINE LABIN,
CROATIA

DIVINE SPRINGS

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MENTOR: Olivera Tadić

Path of Divine Springs

Water is the source of life, and the springs were once the source of life for the people in Labin.
Therefore, we decided to follow the path of Divine Springs, which starts in Maslinica Bay in Rabac. The path towards the old town of Labin meanders through the most beautiful protected natural landscape in the area of Labin. The springs Vrućak and Blažićevo are situated next to the big waterfall and small streams will follow you on your way up the hill. The waterfalls of the Pećina stream flow over the winding travertine barriers and one of the springs is hidden in the mysterious Negri cave. We continue further up towards the Old Town and find more nameless springs until we come to the Šćurak spring that lies at the very foot of the city walls in Podvinje. Once the main town spring, the Šćurak spring and its surroundings represented a large urban garden where the women brought the water by carrying it in heavy buckets.

Photo 1 Divine Springs Trail **(TRAIL 3.)**
Source: https://www.rabac-labin.com

1. RESEARCH QUESTIONS AND HYPOTHESIS

We talked with the officials from the local water supply company "Vodovod Labin" and we found out that their competence does not include the DIVINE SPRINGS and that there is no data on the quality of water. However, they were more than ready to help us in our research.

We believe that with the data collected in this project, we will be able to map the localities of the springs, determine the type of cover that surrounds them and, most importantly, determine if spring water meets the basic drinking water quality parameters.

Bearing in mind that during the summer months this path is full of tourists who tend to drink the water from the springs, we came to the following **research question:**

Can water from the Divine Springs be used for drinking?

PARTICIPANTS

GLOBE GROUP: 15 members
OTHER STUDENTS: 30 students
} **TOTAL: 45 students**

PERIOD OF WORK: School year 2019 /2020

PROJECT ASSOCIATES:

- Labin–Rabac Tourist Bord
- "Zdravi grad Labin"
- Association "Alfa Albona"
- Association Water supply company "Vodovod Labin"
- Karmen Diminić Milevoj

LABIN ZDRAVI GRAD

VODOVOD LABIN d.o.o.
za javnu vodoopskrbu i odvodnju

Rabac • Labin

ALFA ALBONA

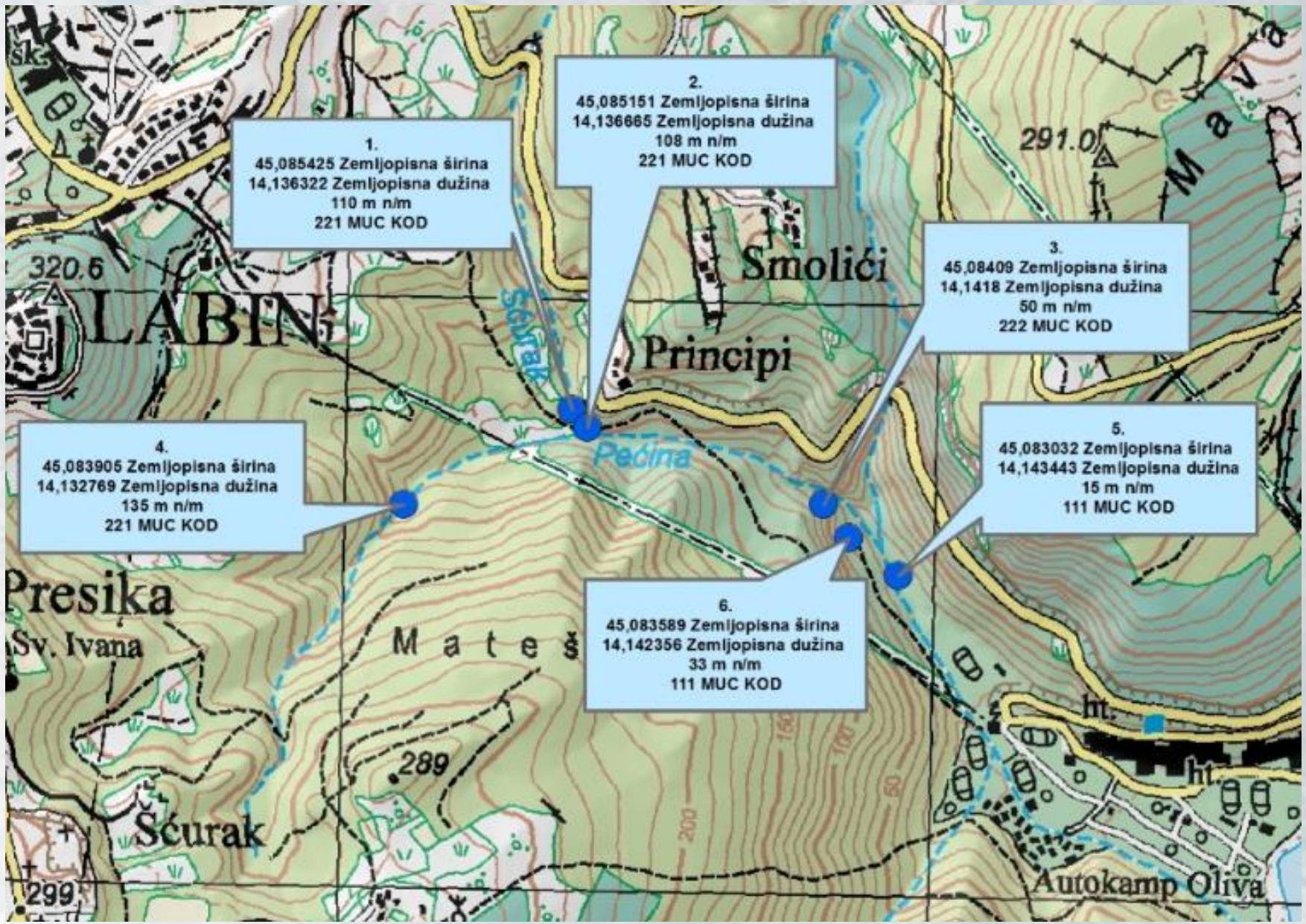
Forty-five students of different age groups were divided into teams and they participated in activities in which they tried to find out more about the locations, the cover and physical-chemical and microbiological characteristics of **6** springs.

Photo 2 Divine springs
Source: our own making

2. Research methods

ACTIVITIES	METHODS
1.Determining spring coordinates	- GLOBE GPS protocols
2. Determining the natural surroundings	- GLOBE MUC protocols
3. Development of the map of the path and the springs	- DIGITAL CARTOGRAPHY
4. Physical-chemical water analysis	- GLOBE hydrological protocols
5. Physical-chemical and microbiological water analysis	- "VODOVOD" - LABORATORY FOR WATER QUALITY ANALYSIS www.vodovod- labin.hr
6. Comparison with the official data	- Regulation from the Official Gazette 125/2017 Act on Water for Human Consumption (Official Gazette 56/13 , 64/15, 104/17)

3. RESULTS



3.1. DETERMINING SPRINGS COORDINATES

Photo 3 Topographic map
Source: our own design

3.2. CREATION OF THE MAP OF THE PATH AND THE SPRINGS

Photo 4 Satellite map
Source: our own design

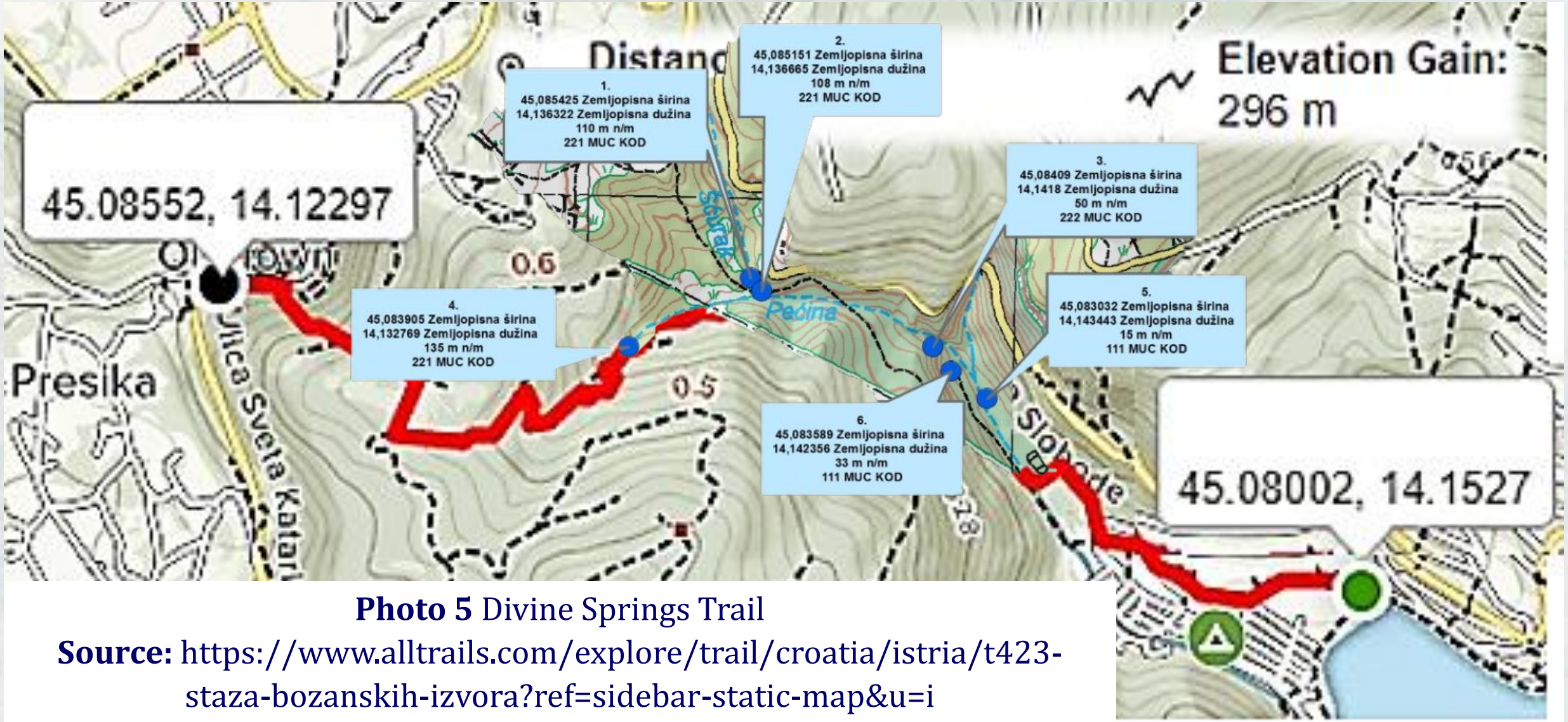


Photo 5 Divine Springs Trail

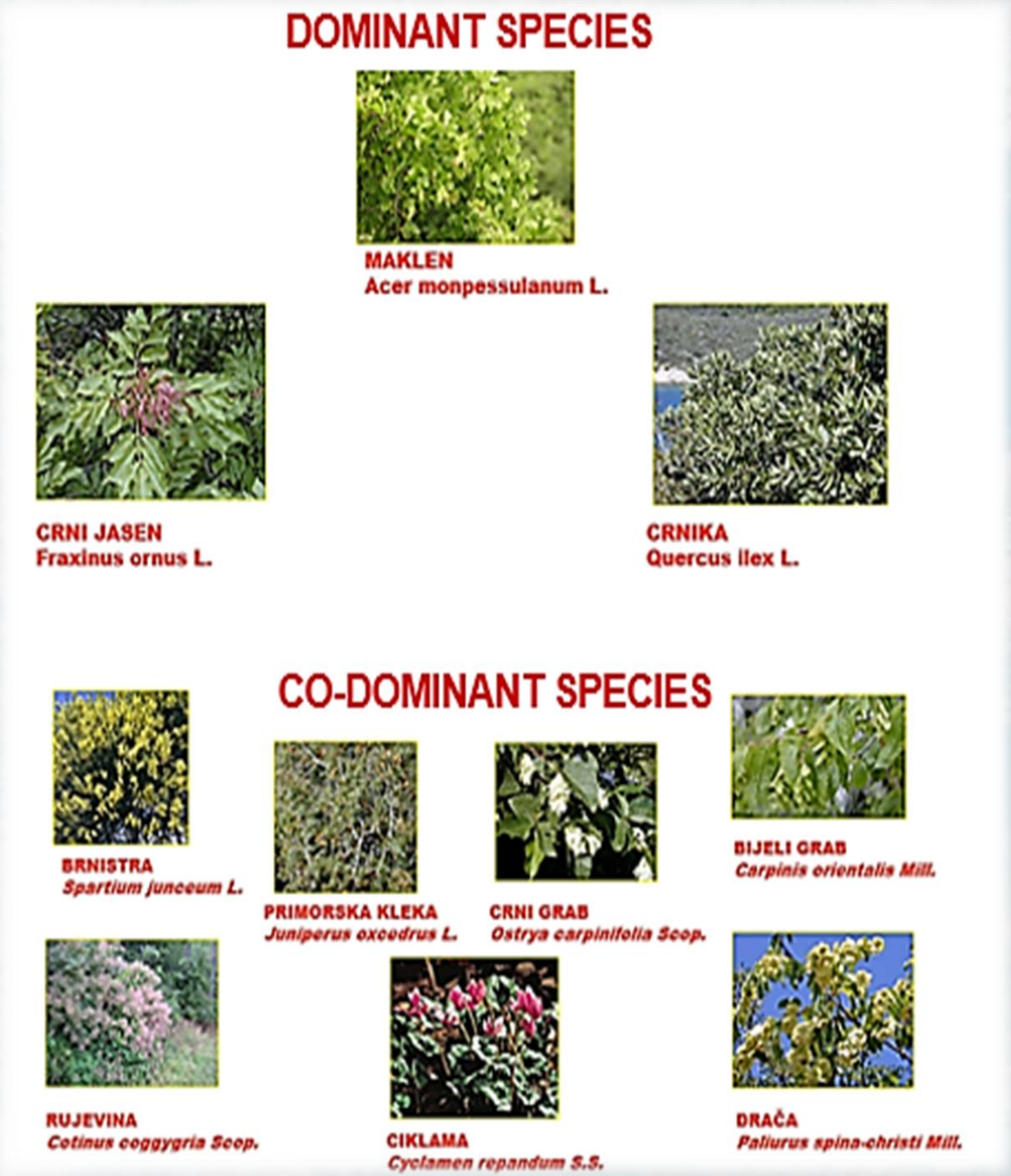
Source: https://www.alltrails.com/explore/trail/croatia/istria/t423-staza-bozanskih-izvora?ref=sidebar-static-map&u=i

If we compare these maps with the one presented in Photo 1, it is evident that the springs are located along the entire path.

3.3. DETERMINING THE NATURAL SURROUNDINGS

Table 1 Cover and MUC code **Source:** our own desing

SPRING NUMBER	MUC CODE	DOMINANT AND CO-DOMINANT SPECIES
1.	**221** Deciduous in dry periods, mixed with evergreen broad-leaved trees and climbers.	**DOMINANT SPECIES:** MONTPELLIER MAPLE **CO-DOMINANT SPECIES:** CADE JUNIPER, HOP HORNBEAM, GARLAND THORN
2.	**221** Deciduous in dry periods, mixed with evergreen broad-leaved trees and climbers.	**DOMINANT SPECIES:** MONTPELLIER MAPLE **CO-DOMINANT SPECIES**: CADE JUNIPER, HOP HORNBEAM, GARLAND THORN
3.	**222** Deciduous in dry periods, mixed with evergreen needle-leaved trees.	**DOMINANT SPECIES:** FLOWERING ASH **CO-DOMINANT SPECIES**: ORIENTAL HORNBEAM, EURASIAN SMOKE TREE
4.	**221** Deciduous in dry periods, mixed with evergreen broad-leaved trees and climbers.	**DOMINANT SPECIES:** MONTPELLIER MAPLE **CO-DOMINANT SPECIES:** CADE JUNIPER, HOP HORNBEAM, GARLAND THORN
5.	**111** Evergreen broad-leaved forest	**DOMINANT SPECIES:** HOLM OAK **CO-DOMINANT SPECIES:** FLOWERING ASH, SPANISH BROOM
6.	**111** Evergreen broad-leaved forest	**DOMINANT SPECIES**: HOLM OAK **CO-DOMINANT SPECIES:** FLOWERING ASH, CYCLAMEN



The Divine Springs Trail belongs to the protected landscape area of Labin-Rabac-Prklog and is a true pearl that deserves to be admired.

The path is rather **short**, but exceptionally beautiful, immersed in the thick sub-Mediterranean vegetation, characteristic for the cooler and more humid type of Mediterranean climate that can be found throughout the eastern coast of the Istrian peninsula. This was confirmed by determining the **MUC Codes.**

Photo 6 Plant cover
Source: our own design

QUALITY OF SPRING WATER

Samples were taken two times a week in the period from 16. 09. 2019 to 12. 01. 2020 and were analysed in the school laboratory in accordance with the GLOBE hydrological protocols.

During the final sampling (12. 01. 2020.), we took the sample from each spring and brought it to VODOVOD LABIN in order to obtain the data we could compare our results with.

Healthy water for human consumption is the water which has the following characteristics:

- does not contain micro-organisms, parasites and their developmental forms in the amount that would endanger human health
- does not contain harmful substances in concentrations that could, individually or combined with other substances, endanger human health
- does not exceed the values of healthy water parameters, prescribed by the **Regulation on the parameters of assessment and methods of analysis of water for human consumption (Official Gazette 125/17)**

3.4. PHYSICAL-CHEMICAL INDICATORS

Table 2 Physical - chemical analysis of water **Source:** our own design

SPRING 1						
INDICATOR	MEASUREMENT UNIT	MPC	CONTROL WATER SUPPLY	AVERAGE	SAMPLE NUMBER	INACCURATE SAMPLES
Temperature	°C	25	-	21	30	0
Colour		no	-	no	30	0
Turbidity	visually/NTU	no / 4	0,5	no	30	0
Taste		no	-	no	30	0
Odour		no	-	no	30	0
Concentration of hydrogen ions	pH unit	6,5-9,5	8,0	7,5	30	0
Conductivity	μScm^{-1}/20°C	2500	509	582,7	30	0
Total hardness	$CaCO_3$ mg L^{-1}	>60	259,0	253,6	30	0
Ammoniac	$mgNH_4^+ L^{-1}$	0,5	0,0	0,0	30	0
Nitrites	$mgNO_2^- L^{-1}$	0,5	0,0	0,0	30	0
Nitrates	$mgNO_3^- L^{-1}$	50	3,1	0,0	30	0
Chlorides	$mgCl^- L^{-1}$	250	18,1	0,0	30	0
Sulphates	$mgSO_4^{2-} L^{-1}$	< 200	12,3	< 200	30	0
Dissolved oxygen	$mgO_2 L^{-1}$	>7	6,59	6,71	30	5
Consumption of $KMnO_4$	$mgO_2 L^{-1}$	5,0	0,54	0,58	30	0

Photo 7 Spring 1.
Source: our own design

Table 3 Physical - chemical analysis of water
Source: our own design

SPRING 2						
INDICATOR	MEASUREMENT UNIT	MPC	CONTROL WATER SUPPLY	AVERAGE	SAMPLE NUMBER	INACCURATE SAMPLES
Temperature	°C	25	-	21	30	0
Colour		no	-	no	30	0
Turbidity	visually/NTU	no / 4	1,2	no	30	0
Taste		no	-	no	30	0
Odour		no	-	no	30	0
Concentration of hydrogen ions	pH unit	6,5-9,5	7,9	7,3	30	0
Conductivity	μScm^{-1}/20°C	2500	486	537,3	30	0
Total hardness	$CaCO_3$ mg L^{-1}	>60	241,1	243,6	30	0
Ammoniac	$mgNH_4^+ L^{-1}$	0,5	0,0	0,0	30	0
Nitrites	$mgNO_2^- L^{-1}$	0,5	0,0	0,0	30	0
Nitrates	$mgNO_3^- L^{-1}$	50	3,1	0,0	30	0
Chlorides	$mgCl^- L^{-1}$	250	16,3	0,0	30	0
Sulphates	$mgSO_4^{2-} L^{-1}$	<200	14,9	<200	30	0
Dissolved oxygen	$mgO_2 L^{-1}$	>7	6,87	7,3	30	1
Consumption of $KMnO_4$	$mgO_2 L^{-1}$	5,0	0,51	0,53	30	0

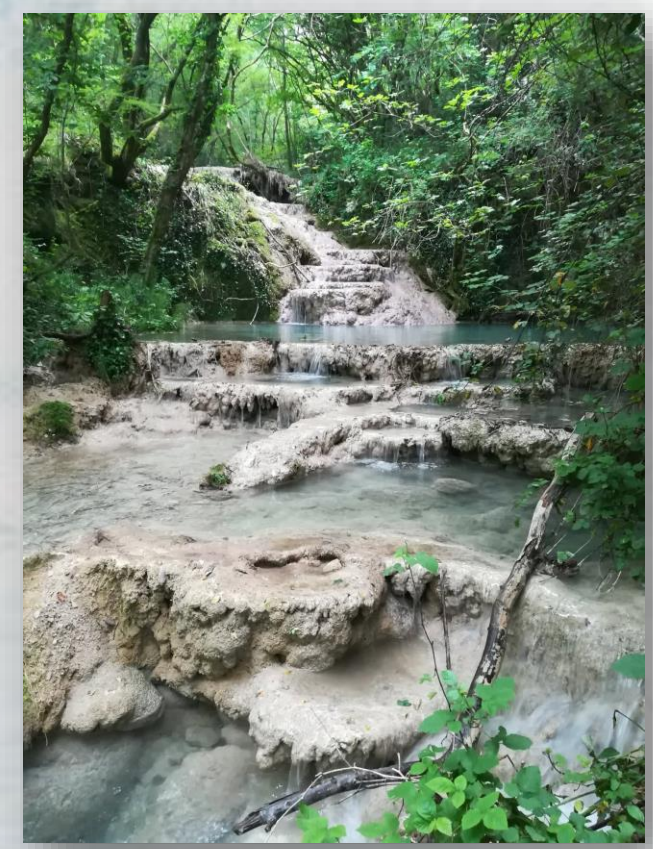


Photo 8 Spring 2.
Source: our own design

Table 4 Physical - chemical analysis of water

Source: our own design

SPRING 3						
INDICATOR	MEASUREMENT UNIT	MPC	CONTROL WATER SUPPLY	AVERAGE	SAMPLE NUMBER	INACCURATE SAMPLES
Temperature	^{o}C	25	-	21	30	0
Colour		no	-	no	30	0
Turbidity	visually/NTU	no/ 4	1,2	no	30	0
Taste		no	-	no	30	0
Odour		no	-	no	30	0
Concentration of hydrogen ions	pH unit	6,5-9,5	7,9	7,2	30	0
Conductivity	$\mu Scm^{-1}/20°C$	2500	487	557	30	0
Total hardness	$CaCO_3$ mg L^{-1}	>60	244,7	254,8	30	0
Ammoniac	$mgNH_4^+ L^{-1}$	0,5	0,0	0,0	30	0
Nitrites	$mgNO_2^- L^{-1}$	0,5	0,0	0,0	30	0
Nitrates	$mgNO_3^- L^{-1}$	50	2,4	0,0	30	0
Chlorides	$mgCl^- L^{-1}$	250	17,1	0,0	30	0
Sulphates	$mgSO_4^{2-} L^{-1}$	< 200	14,9	<200	30	0
Dissolved oxygen	$mgO_2 L^{-1}$	>7	6,88	7,3	30	1
Consumption of $KMnO_4$	$mgO_2 L^{-1}$	5,0	0,48	0,51	30	0

Photo 9 Spring 3.

Source: our own design

Table 5 Physical - chemical analysis of water

Source: our own design

SPRING 5						
INDICATOR	MEASUREMENT UNIT	MPC	CONTROL WATER SUPPLY	AVERAGE	SAMPLE NUMBER	INACCURATE SAMPLES
Temperature	°C	25	-	21,5	30	0
Colour		no	-	no	30	0
Turbidity	visually/NTU	no/ 4	0,3	no	30	0
Taste		no	-	no	30	0
Odour		no	-	no	30	0
Concentration of hydrogen ions	pH unit	6,5-9,5	8,0	7,6	30	0
Conductivity	$\mu Scm^{-1}/20°C$	2500	434	451	30	0
Total hardness	$CaCO_3$ mg L^{-1}	>60	234	230	30	0
Ammoniac	$mgNH_4^+ L^{-1}$	0,5	0,0	0,0	30	0
Nitrites	$mgNO_2^- L^{-1}$	0,5	0,0	0,0	30	0
Nitrates	$mgNO_3^- L^{-1}$	50	2,0	0,0	30	0
Chlorides	$mgCl^- L^{-1}$	250	17,5	0,0	30	0
Sulphates	$mgSO_4^{2-} L^{-1}$	< 200	19,0	<200	30	0
Dissolved oxygen	$mgO_2 L^{-1}$	>7	7,53	7,10	30	0
Consumption of $KMnO_4$	$mgO_2 L^{-1}$	5,0	0,64	0,63	30	0

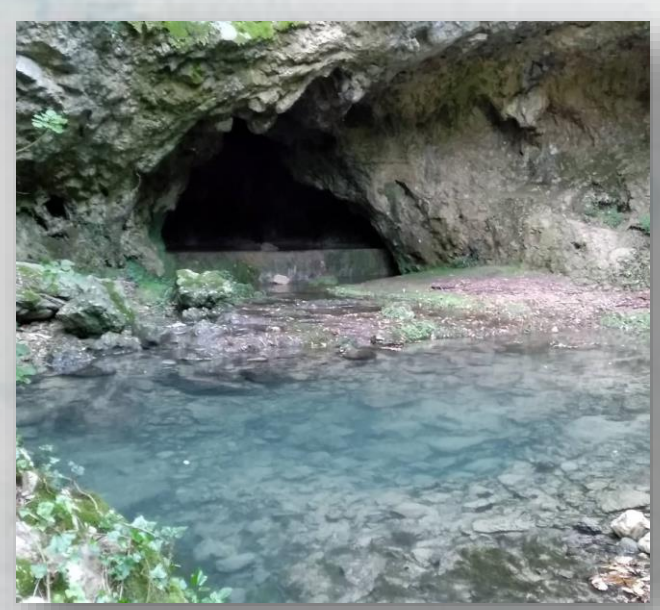


Photo 10 Spring 4.

Source: our own design

Table 6 Physical - chemical analysis of water
Source: our own design

SPRING 5						
INDICATOR	MEASUREMENT UNIT	MPC	CONTROL WATER SUPPLY	AVERAGE	SAMPLE NUMBER	INACCURATE SAMPLES
Temperature	°C	25	-	21,5	30	0
Colour		no	-	no	30	0
Turbidity	visually/NTU	no/ 4	0,3	no	30	0
Taste		no	-	no	30	0
Odour		no	-	no	30	0
Concentration of hydrogen ions	pH unit	6,5-9,5	8,0	7,6	30	0
Conductivity	μScm^{-1}/20°C	2500	434	451	30	0
Total hardness	$CaCO_3$ mg L^{-1}	>60	234	230	30	0
Ammoniac	$mgNH_4^+ L^{-1}$	0,5	0,0	0,0	30	0
Nitrites	$mgNO_2^- L^{-1}$	0,5	0,0	0,0	30	0
Nitrates	$mgNO_3^- L^{-1}$	50	2,0	0,0	30	0
Chlorides	$mgCl^- L^{-1}$	250	17,5	0,0	30	0
Sulphates	$mgSO_4^{2-} L^{-1}$	< 200	19,0	<200	30	0
Dissolved oxygen	$mgO_2 L^{-1}$	>7	7,53	7,10	30	0
Consumption of $KMnO_4$	$mgO_2 L^{-1}$	5,0	0,64	0,63	30	0

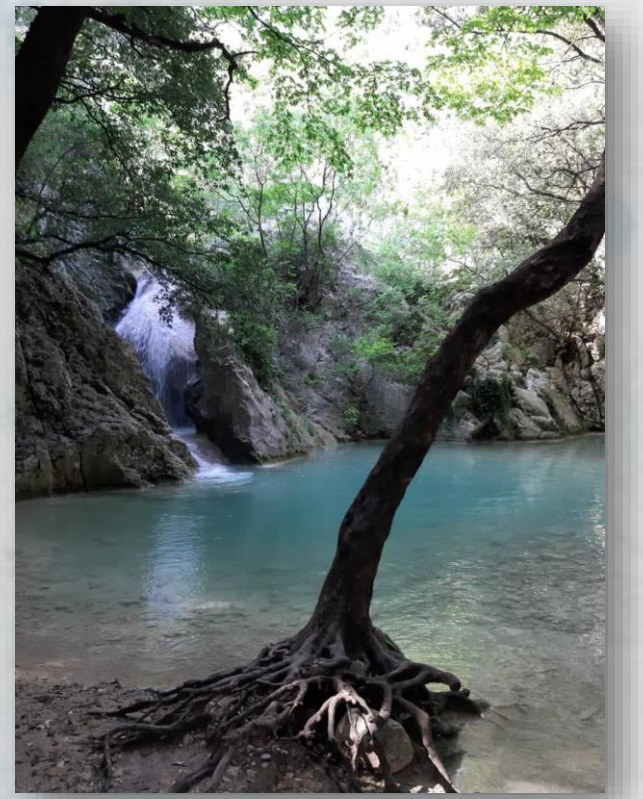


Photo 11 Spring 5.
Source: our own design

Table 7 Physical - chemical analysis of water
Source: our own design

SPRING 6						
INDICATOR	MEASUREMENT UNIT	MPC	CONTROL WATER SUPPLY	AVERAGE	SAMPLE NUMBER	INACCURATE SAMPLES
Temperature	°C	25	-	21,5	30	0
Colour		no	-	no	30	0
Turbidity	visually/NTU	no/ 4	0,3	no	30	0
Taste		no	-	no	30	0
Odour		no	-	no	30	0
Concentration of hydrogen ions	pH unit	6,5-9,5	8,2	7,9	30	0
Conductivity	μScm^{-1}/20°C	2500	432	460,3	30	0
Total hardness	$CaCO_3$ mg L^{-1}	>60	221,5	223,0	30	0
Ammoniac	$mgNH_4^+ L^{-1}$	0,5	0,0	0,0	30	0
Nitrites	$mgNO_2^- L^{-1}$	0,5	0,0	0,0	30	0
Nitrates	$mgNO_3^- L^{-1}$	50	2,0	0,0	30	0
Chlorides	$mgCl^- L^{-1}$	250	17,6	0,0	30	0
Sulphates	$mgSO_4^{2-} L^{-1}$	< 200	19,0	<200	30	0
Dissolved oxygen	$mgO_2 L^{-1}$	>7	7,07	6,7	30	3
Consumption of $KMnO_4$	$mgO_2 L^{-1}$	5,0	0,65	0,66	30	0

Photo 12 Spring 6.
Source: our own design

3.5. COMPARED RESULTS WITH THE LEGAL NORMS

When we compared our results with the legal norms, we noticed a slight discrepancy in the amount of dissolved oxygen in the springs 1, 4 and 6, in the samples with water temperature of 23^{o}C, and this affected the reduced solubility of oxygen.

According to the Regulation on the parameters of assessment and methods of analysis of water for human consumption (Official Gazette 125/17), dissolved oxygen is not the obligatory parameter in the monitoring of water for human consumption, but it is more important for surface water and life in it, and the reduced amounts of dissolved oxygen do not affect the possibility of using water from these springs for drinking, bearing in mind that all other physical-chemical indicators comply with the norms of this Regulation.

3.6. MICROBIOLOGICAL INDICATORS

In order to gain a better insight into the health safety of spring water, VODOVOD LABIN analysed the microbiological indicators that cannot be determined in our school laboratory.

Table 8 Microbiological analysis of water **Source:** our own design

INDICATOR	MEASUREMENT UNIT	MPC	SPRING 1	SPRING 2	SPRING 3	SPRING 4	SPRING 5	SPRING 6
Number of colonies 22 °C	number / 1 ml	100	338	451	1037	64	2040	328
Number of colonies 36 °C	number / 1 ml	100	70	127	93	21	31	26
Total Coliforms	number /100 ml	0	33	66	34	0	214	160
Escherichia coli (E. coli)	number/100 ml	0	18	29	8	0	19	26
Enterococci	number/100 ml	0	3	2	0	0	3	2
Pseudomonas aeruginosa	number/100 ml	0	0	0	0	0	0	0

Although some microbiological indicators do not comply with legal standards, the experts in VODOVOD Labin told us that these values were expected when it comes to natural springs and that the water can be used for drinking during a short period of time without any threat to human health.

4. Discussion

By comparing our results with the data available online and in literature, we are very pleased with what we have achieved.

Our map shows that the springs are distributed along the entire path, and by determining the coordinates we enabled the Labin City Tourist Board to mark these locations in their promotional materials.

As expected, the cover along the path belongs to the sub-Mediterranean type of vegetation, characteristic for the cooler and more humid Mediterranean climate, with Montpellier maple, flowering ash and holm-oak as the dominant species.

Physical-chemical indicators of spring water are within the legal norms; and although the microbiological indicators are slightly higher than those prescribed by the standards, which is expected for natural springs, they are still within the limits that allow the use of spring water for drinking without endangering human health.

5. Conclusion

We hereby come to the answer to our research question and we can conclude that the water from divine sources can be used for drinking without endangering human health.

The results of this research give the Divine Sources Trail an extra value because recreationists, tourists and other visitors of the path can enjoy fresh drinking water along their way surrounded by pure natural beauties.

6. Bibliography

LITERATURE:

- HRVATSKE VODE, AMENDMENT TO THE WATER SUPPLY PLAN OF THE REGION OF ISTRIA, BOOK 1 Zagreb, November 2016

INTERNET:

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- https://www.rabac-labin.com/hr/166-staza-bozanskih-izvora-rabac-labin (date of access 23.09.2019.)
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7. Acknowledgements

- We thank the members of our group and other students for their dedicated work in the project and we all learned a lot of environmental factors in the environment.

- We thank our mentor Olivera Tadić, Globe teacher & teacher mentor, graduate engineer of chemical technology, who has been working on environmental issues for 15 years, for her support.

8. Badges

Collaboration: We collaborated with two Globe teachers-mentors during this project.
Our mentors showed us how to use the GLOBE protocols and method of digital cartography.
We also collaborated with other members of the GLOBE group and other students from our school during our field work. They helped us to determine the coordinates of locations using the GPS method.

Community Impact: We have presented our results to the GOVERNMENT and TOURIST AGENCY and they have shown great interest, so we believe that our map will be part of the tourist promotion of our region. We published our results in the media (Glas Istre i TV Istra)

Connecting with A STEM Professional: We collaborated with scientists from VODOVOD LABIN d.o.o. who provided us with microbiological analysis of water in their laboratory and with Karmen Milevoj Diminić, geography professor and GLOBE teacher who introduced us to the methods of digital cartography.