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MONITORING OF WATERS IN THE "PLAVICA" CONCESSION AREA

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Abstract
This paper presents the results of the regular monthly monitoring of the quality of underground and surface water in the "Plavica" locality and the surrounding area in order to identify potential pollutants and monitor changes in the ecosystems. Through monthly sampling and analyses of water from different sources, certain chemical and physical parameters have been identified, including pH value, heavy metal concentrations and the presence of organic pollutants.
The investigations of the chemical composition of the water from the studied terrain indicate that the lithological composition of the terrain, through which the underground water moves, has the greatest influence, and at the same time, the retention time of the underground water before it appears in the source, is also affected. Research has shown that monitoring sites for water quality control of surface watercourses SW2, SW3 and SW10, as well as monitoring sites for groundwater control B1 and I-16, indicate the presence of acidic waters (pH<4) with metal contents higher than MKD of which iron, copper, cadmium, lead, arsenic, mercury and zinc deserve special attention, even before the start of mining activities.

Keywords: *Monitoring, spring, well, borehole, surface and underground water, chemical composition of water, heavy metals, Plavica*

INTRODUCTION

The Cu-Au deposit "Plavica" is part of the Kratovo-Zletovo volcanic area located in the northeastern part of the Republic of North Macedonia, occupying the central part of Mount Plavica (1290 m) between the cities of Kratovo and Probishtip.

The geological setting of the Plavica deposit, as well as its structural-tectonic characteristics, are only a part of the very complex Kratovo-Zletovo volcanic area where volcanic rocks dominate, intensively hydrothermally altered, brecciated and tectonically displaced in different directions (Zlatkov G., Serafimovski T. et al., 2014)[4]. In the geological structure of the narrower environment of the Plavica deposit, mostly volcanic and volcanogenic-sedimentary rocks participate in the intense presence of hydrothermal alterations. The most represented lithological members are ignimbrites, stratified volcanic tuffs, breccias, dacito-andesites and vuggy silica. Significant contents of polymetallic mineralization are found in silicate bodies and porous geological environments. The ore mineralization is created mainly by filling the voids within the fissure-fault systems, veins, and veins, and it is metasomatically impregnated into the surrounding hydrothermally altered volcanic rocks.

From a hydrogeological point of view, the deposit "Plavica" was treated and studied for the first time by Geoengineering M DOOEL - Skopje [3]. With the hydrogeological research carried out at that time, a preliminary assessment of the filtration characteristics of the environment was given, then an observation network was formed, underground leakage was determined through the monitoring of sources, based on which dynamic reserves were determined, further hydrochemical parameters of the underground waters were given, etc.

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Additional and expanded hydrogeological surveys within this area were conducted by „Genesis Resources International“ together with Golder Associates [1]. Summary results, for all hydrogeological surveys and field investigations performed so far, are presented by the Construction Institute of Macedonia [2].

Within the broader environment of the research area, according to the lithological structure and hydrogeological characteristics, the following are represented: lithological environments with intergranular porosity in which a compact type of outcrop (alluvial sediments) was formed; lithological environments with fissure porosity in which a fissure type of outcrop is formed (tuffs; Miocene sediments), lithological environments that are conditionally impermeable and anhydrous (dacites and andesites, ignimbrites of andesitic composition, dacitoandesites, quartzites, slates), as well as impermeable lithological environments and anhydrous (Eocene flysch).

According to the water permeability, ie. the hydrogeological function of the rock masses, the same in the research area were distinguished as poorly to medium permeable environments in which a compact type of outcrop was formed and had the function of a hydrogeological collector; poorly permeable environments with fissure porosity in which a fissure type of outcrop is formed and have the function of a hydrogeological collector; as well as conditionally impermeable environments with conditions of intermittent occurrence of fissure porosity and local formation of outcrop with limited distribution, which mainly play the role of a hydrogeological insulator, with a local function of a hydrogeological collector or conductor.

In order to monitor the quality of water from springs, exploratory boreholes and surface watercourses within the area in question, water samples were taken from all monitoring places.

METHODOLOGY

In this paper, the results of water quality testing samples taken from several locations in and around the locality "Plavica" are attached. The locations from which water samples were taken for analysis are shown in Figure 1, while the measuring points are shown in Table 1.

In order to examine the quality of water, i.e. to determine the basic properties of water from springs, exploratory boreholes and surface watercourses within the concession area and the surrounding area, water samples were taken several times from all monitoring points, and a certain number of analyses were made. Every month, field determination of the physical characteristics of water was carried out on site using the Smart TROLL MP type instrument manufactured by the company "In-Situ Inc" from America. Every three months, chemical analyses of water samples were made in separate plastic bottles of 1 and 5 l and Winkler bottles of 250 ml - to which fixation reagents were added - with manganese sulfate 2 ml and sodium iodide 1 ml.

The current analyses of the water were carried out in an accredited laboratory at the "Goce Delchev" University in Shtip (UNILAB). The method used for the analyses is ICP-MS (Inductively Coupled Plasma Mass Spectrometry), which is highly precise and sensitive for the detection of metallic and non-metallic elements in water samples.

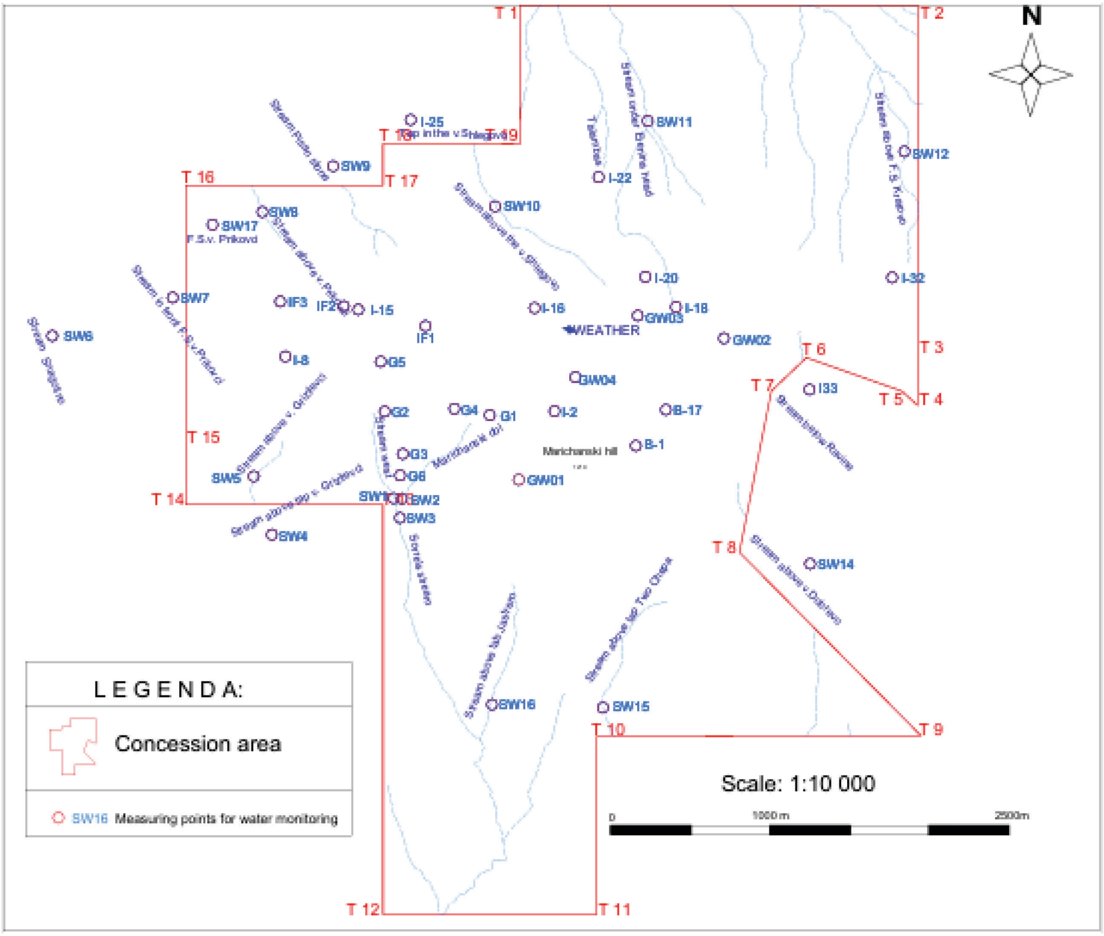

Figure 1. Map of monitoring sites of surface and groundwater samples taken

Table 1. Measurement places of the exploration area

Measuring place	Description of measuring place	Coordinates		Measuring place	Description of measuring place	Coordinates	
		X	Y			X	Y
SW1	stream	4 656 038	7 596 307	I-20	source	4 657 426	7 597 889
SW2	stream	4 656 036	7 596 359	I-22	source	4 658 051	7 597 595
SW3	stream	4 655 915	7 596 347	I-25	tap water	4 658 410	7 596 415
SW4	stream	4 655 810	7 595 542	I-32	source	4 657 422	7 599 440
SW5	stream	4 656 176	7 595 428	I-33	tap water	4 656 719	7 598 920
SW6	stream	4 657 056	7 594 142	B-1	well	4 656 367	7 597 829
SW7	stream	4 657 296	7 594 919	B-17	well	4 656 593	7 598 018
SW8	stream	4 657 833	7 595 483	GW 01	borehole	4 656 156	7597 093
SW9	stream	4 658 120	7 595 927	GW 02	borehole	4 657 041	7 598 384
SW10	stream	4 657 868	7 596 945	GW 03	borehole	4 657 184	7 597 842
SW11	stream	4 658 403	7 597 904	GW 04	borehole	4 656 797	7 597 449
SW12	stream	4 658 212	7 599 517	G1	borehole	4 656 580	7 596 918
SW14	stream	4 655 627	7 598 924	G2	borehole	4 656 582	7 596 250
SW15	stream	4 654 726	7 597 623	G3	borehole	4 656 313	7 596 365
SW16	stream	4 654 745	7 596 926	G4	borehole	4 656 602	7 596 686
SW17	Filter station in the village of Prikovci	4 657 753	7 597 169	G5	borehole	4 656 896	7 596 226
I-2	source	4 656 584	7 597 318	G6	borehole	4 656 182	7 596 350
I-8	source	4 656 927	7 595 627	IF1	borehole	4 657 118	7 596 507
I-15	source	4 657 221	7 596 085	IF2	borehole	4 657 241	7 595 989
I-16	source	4 657 231	7 597 193	IF3	borehole	4 657 270	7 595 594
I-18	source	4 657 237	7 598 071				

1. Results and discussion

There are 20 monitoring points for measuring water flow. From the data from regular monthly measurements of these sources, it is seen that the output of the sources is variable and relatively small, while the smaller sources dry up over the summer and autumn periods. The total average yield for all sources was monitored for the period July 2017 - 2024 is about Qsr.= 0.14 l/s.

The results obtained from the performed water flow measurement are shown in Table 2.

Table 2. Results of the measured flow of water

Date	Location	Average of water (l/sec)
08.4.2021	SW1	1.81818
08.4.2021	SW2	4.00000
08.4.2021	SW3	6.66666
05.4.2021	SW4	5.71428
05.4.2021	SW5	5.00000
02.4.2021	SW6	10.0000
02.4.2021	SW7	2.22222
02.4.2021	SW8	3.07692
02.4.2021	SW9	5.0000
02.4.2021	SW10	20.00000
01.4.2021	SW11	1.0000
01.4.2021	SW12	4.0000
01.4.2021	SW13(I-33)	0.125
01.4.2021	SW14	6.66666
05.4.2021	SW15	2.85714
05.4.2021	SW16	1.42857
05.4.2021	I-15	no flow
06.4.2021	I-16	0.25641
01.4.2021	I-22	1.33333
01.4.2021	I-25	no flow

After the exploratory drilling of each of the boreholes, the piezometer constructions were installed in them. The purpose is to measure the NPV (groundwater level). Table 3 shows the results of the NPV measurement.

Table 3. Results of NPV (groundwater level)

Tag	Depth (m)	Coordinates			Relatively NPV max/min(m)	Note
		X	Y	Z		
G1	40	7 596 920	4 656 578	950,38	1.80-4.45	In the borehole GW04 is not ascertained NPV
G2	40	7 596 251	4 656 582	916,87	7.15-10.68	
G3	40	7 596 365	4 656 316	918,07	16.24-23.68	
G4	40	7 596 689	4 656 599	987,17	26.30-30.33	
G5	40	7 596 226	4 656 895	976,64	1.78-4.57	
G6	40	7 596 348	4 656 182	861,39	25.60-27.84	
GW01	40	7 597 093	4 656 156	1106,19	39.08-39.89	
GW02	50	7 598 384	4 657 040	1281,99	34.39-49.84	
GW03	40	7 597 843	4 657 184	1195,9	14.43-19.55	
GW04	40	7 597 444	4 656 793	1126,32	/	
IF1	20	7 596 507	4 657 118	1106,85	4.10-18.90	
IF2	20	7 595 994	4 657 242	1061,1	3.49-10.20	
IF3	20	7 595 595	4 657 272	1013,03	3.50-8.07	

Measurement of NPV was performed on 13 exploratory boreholes. The depth of the boreholes is from 20 to 40 m, except for GW02 = 50 m.

It can be seen from the attached Table 3 that the level of underground water is very variable and ranges from 1.80 to 49.89 m. The biggest difference in the measured values of NPV variation is in the borehole IF1 and, it is 14.80 m. while the smallest is in GW01, and it is 0.80 m. while the average ranges from 2.5-4 m. The attached table also shows that there is no water in borehole GW04, and in boreholes GW01, GW02 and IF1, the level is very deep or close to the bottom. Such variations in NPV are probably due to the weather conditions that prevailed during the period of the measurements and, to a certain extent, the permeability and water permeability of the rock masses.

As part of these activities, measurements of certain physical parameters of the water were carried out with the Smart TROLL MP instrument. The results obtained from these studies are shown in Table 4.

Table 4. Physical results of water from SmarTROLL MP instrument

Name of the measuring point	Date	Pressure (psi)	Instantaneous conductance (µS/cm)	Temperature (°C)	Saltiness (ppt)	Resistivity (Ωcm)	Density (g/cm³)	pH (pH)
SW1	17.10.2018	-0,08	1208,1	17,2	0,717	827,8	0,999	4,0
SW2	17.10.2018	-0,04	1812,9	19,1	1.053	551,6	0,999	3,1
SW3	17.10.2018	-0,06	1422,9	16,7	0,861	702,8	0,999	3,5
SW4	17.10.2018	/	/	/	/	/	/	/
SW5	17.10.2018	/	/	/	/	/	/	/
SW6	16.10.2018	-0,05	520,9	13,5	0,326	1919,7	0,999	8,0
SW7	16.10.2018	/	/	/	/	/	/	/
SW8	16.10.2018	/	/	/	/	/	/	/
SW9	16.10.2018	-0,08	429,2	11,8	0,278	2329,8	0,999	7,8
SW10	16.10.2018	-0,04	683,7	12,8	0,440	1462,7	0,999	3,5
SW11	15.10.2018	-0,03	416,4	20,38	0,222	2401,4	0,998	8,0
SW12	15.10.2018	/	/	/	/	/	/	/
SW13	15.10.2018	-0,05	409,9	16,6	0,237	2439,1	0,999	5,9
SW14	15.10.2018	/	/	/	/	/	/	/
SW15	17.10.2018	/	/	/	/	/	/	/
SW16	17.10.2018	/	/	/	/	/	/	/
SW17	16.10.2018	-0,07	47,3	13,3	0,028	21126,8	0,999	8,8
I-15	19.10.2018	/	/	/	/	/	/	/
I-15	18.10.2018	-0,07	59,43	12,8	0,036	16826,8	0,999	5,4
I-16	15.10.2018	/	/	/	/	/	/	/
I-25	16.10.2018	-0,04	331,9	14,6	0,200	3013,1	0,999	6,7
B1	18.10.2018	-0,07	93,0	13,5	0,056	10748,4	0,999	7,0
B17	18.10.2018	-0,07	55,2	13,6	0,032	18119,8	0,999	7,1
GW01	19.10.2018	-0,05	519,5	15,4	0,311	1924,9	0,999	7,5
GW02	19.10.2018	/	/	/	/	/	/	/
GW03	19.10.2018	-0,08	198,0	11,8	0,126	5050,9	0,999	7,2
GV04	19.10.2018	/	/	/	/	/	/	/
G1	19.10.2018	-0,05	1251,0	15,4	0,776	799,5	0,999	3,8
G2	25.10.2018	-0,03	355,0	11,6	0,230	2816,7	0,999	7,8
G3	24.10.2018	-0,05	183,6	15,5	0,107	5446,3	0,999	6,6
G4	24.10.2018	-0,05	819,7	14,9	0,504	1219,9	0,999	7,5
G5	24.10.2018	-0,03	156,6	15,9	0,090	6383,0	0,999	8,3
G6	25.10.2018	-0,03	1302,7	11,8	0,883	767,6	1.000	7,5
IF1	25.10.2018	-0,06	321,3	9,0	0,223	3112,1	0,999	7,7
IF2	25.10.2018	-0,03	440,6	10,0	0,300	2269,4	0,999	8,1
IF3	25.10.2018	-0,05	246,3	12,8	0,154	4059,8	0,999	8,1

As can be seen from the data in table 4, waters at measuring points SW1, SW2, SW3, G1, G4 and G6 are characterized with high values of electrolytic conductivity (EC) >1000 µS/cm.

The waters that circulate through the heavily mineralized, that is, the ore parts dissolve them, and they are highly mineralized and have an acidic pH. Acidic waters are associated with mineralized parts of the concession area, while neutral and slightly alkaline waters are associated with unmineralized volcanic rocks. Acidic waters are characteristic of the following measuring points: SW1, SW2, SW3, SW10 and G1, where pH values range from 2-4.

Water hardness refers to the concentration of minerals, especially calcium and magnesium, in the water. Most of the waters represented in the researched area belong to the group of quite hard and hard waters, with values 12-30ºdH (German degree), while a smaller number of water samples belong to the group of soft and very soft waters.

From the table, it can be seen that the temperature is relatively high and ranges between T= 9-20ºC, which is approximately the same as the temperature of most surface watercourses.

The density of water is an important physical parameter and it represents the ratio of the mass of water and its volume at a certain temperature. From the table it can be seen that water has a density of approximately 1.0 g/cm3.

The content of individual elements present in the waters of the researched area was determined in an accredited laboratory for that purpose at the university "Goce Delchev" in Shtip. The results of the performed analyses are shown in Tables 5 and 6.

Table 5. Results of the tests performed in 2018 y.

Label of the element		Al	Sb	As	Cu	Ba	Be	Bi	B	V	Ga	Ge	Fe	Sn	Cd	K	Ca	Co
Unit of measurement		µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
Method		ICP-MS																
Lab. Code	mark	Certain content																
00732	I15	8748	<1	10,1	22	274	<1	5,3	<10	19,1	2,0	<1	2010	<1	1,1	3570	1407	4,3
00769	I16	1202	<1	5,3	6,3	54	<1	3,8	<10	3,8	<1	<1	402	<1	<1	1276	1182	4,4
00775	I25	2696	<1	2,9	224	86	<1	6,9	<10	1,3	1,1	<1	2430	<1	6,5	1996	18189	14,6
00792	I33	58	<1	2,7	7,0	33	<1	4,2	<10	1,4	<1	<1	23	<1	3,9	1980	32856	14,7
00727	IF1	24	1,9	3,5	7,0	102	<1	4,3	<10	1,5	<1	<1	20	<1	<1	3973	74071	9,5
00728	IF2	268	<1	8,0	5,6	224	<1	3,0	<10	2,1	1,2	<1	983	<1	<1	4536	28632	4,4
00729	IF3	1046	<1	4,2	6,2	362	<1	2,5	<10	3,0	1,7	<1	504	<1	<1	3924	49904	3,9
00730	B1	70	<1	2,7	3,5	154	<1	2,3	<10	1,4	<1	<1	17	<1	<1	1166	1531	11,4
00731	B17	10	<1	2,7	3,8	253	<1	2,4	<10	1,3	1,3	<1	11	<1	5,0	2400	1508	5,5
00753	G1	6955	<1	2,5	21695	54	<1	2,2	<10	1,4	<1	<1	30	<1	23,9	2815	49882	33,2
00754	G2	983	<1	3,8	35,9	151	<1	2,3	<10	3,0	<1	<1	983	<1	<1	6409	49778	3,7
00755	G3	65	<1	2,2	8,2	66	<1	1,8	<10	1,3	<1	<1	10	<1	2,5	3891	23798	10,6
00756	G4	12	3,1	3,9	5,7	59	<1	1,5	<10	1,4	<1	<1	20	<1	<1	4096	68575	3,3
00768	G5	<10	<1	2,5	3,2	111	<1	1,5	<10	1,2	<1	<1	27	<1	<1	1643	29658	2,8
00757	G6	<10	<1	4,4	2,5	54	<1	2,1	<10	1,5	<1	<1	32	<1	<1	7899	213535	4,2
00794	GW02	27	<1	2,3	5,5	709	<1	1,8	<10	1,2	2,4	<1	11	<1	<1	1262	17274	2,8
00770	GW03	<10	<1	2,0	2,1	67	<1	1,4	<10	1,0	<1	<1	16	<1	<1	2878	47647	4,3
00733	K001	<10	<1	1,8	2,2	85	<1	1,2	<10	2,2	<1	<1	12	<1	<1	1958	60057	2,3
Label of the element		Li	Mg	Mn	Mo	Na	Ni	Pb	Pd	Se	Ag	Sr	Tl	Ti	Cr	Zn	Au**	Hg**
Unit of measurement		µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
Method		ICP-MS																
Lab. Code	mark	Certain content																
00732	I15	31,9	2157	34	<1	2186	5,5	14,1	2,2	11,2	4,3	338	1,2	32	10,1	15	<1	<1
00769	I16	44,7	1034	118	<1	1166	3,5	8,1	<1	5,1	2,4	218	<1	12	5,7	18	<1	<1
00775	I25	69,5	2823	2324	<1	2716	30,7	192	<1	3,3	6,1	452	3,7	25	4,8	702	<1	<1
00792	I33	78,8	5891	12965	<1	4230	7,3	3,6	<1	3,3	2,5	217	3,6	47	4,1	1330	<1	<1
00727	IF1	75,3	2895	2280	<1	3418	7,8	10,2	<1	4,2	2,1	573	3,3	303	4,7	44,3	<1	<1
00728	IF2	74,4	27301	83	3,6	8175	5,2	17,3	<1	3,4	2,2	314	2,5	35	4,0	11,3	<1	<1
00729	IF3	67,6	4545	31,3	1,6	3687	6,6	8,6	<1	3,3	2,2	196	1,9	69	4,0	9,4	<1	<1
00730	B1	63,9	1475	104	<1	1639	4,8	1,3	<1	3,3	2,0	353	1,7	12	3,6	26	<1	<1
00731	B17	62,8	1367	820	<1	1386	6,1	1,2	<1	3,6	2,0	336	1,5	12	3,6	560	<1	<1
00753	G1	65,5	3900	2141	<1	2774	17,8	350	2,7	3,3	2,0	413	1,6	215	4,1	1073	<1	<1
00754	G2	65,2	8732	66	3,6	5799	4,7	28,8	<1	3,3	1,8	701	1,2	72	3,9	18	<1	<1
00755	G3	62,0	1652	8869	<1	1544	7,9	2,1	<1	2,9	1,7	333	1,1	28	3,4	290	<1	<1
00756	G4	57,1	8237	49,9	5,6	9529	4,6	5,0	<1	3,1	1,6	303	1,1	261	3,5	<10	<1	<1
00768	G5	54,9	2500	69,3	<1	2922	2,9	18,0	<1	2,8	1,5	231	1,0	33	3,2	<10	<1	<1
00757	G6	81,6	97396	237,8	1,5	10251	8,3	1,4	<1	3,5	1,2	1614	<1	1156	3,5	25,6	<1	<1
00794	GW02	66,9	2383	35,9	<1	2086	3,2	6,0	<1	2,7	1,2	375	<1	22	3,1	12,9	<1	<1
00770	GW03	59,7	2099	4503	<1	1883	3,5	<1	<1	2,6	1,2	328	<1	84	2,8	<10	<1	<1
00733	K001	54,8	30306	74,9	<1	19444	3,7	<1	<1	3,2	1,1	283	<1	235	3,2	<10	<1	<1

Table 6. Results of organoleptic and physicochemical properties, April 2018

Parameter		**EC	**pH	**Eh	**Alkalinity $CaCO_3$	**Dissolved Cyanides	**Sulfates SO_4^{2-}	**Nitrites NO_2^-	**Nitrates NO_3^-	**Ammonium NH_4^+	**Dissolved oxygen	**Chlorides Cl^-	**Total phosphorus P	**Total fats and oils
Unit of measure		μs/cm		mV	mg $CaCO_3$/l	μg(CN^-)/l	μg(SO_4^{2-})/l	μg(NO_2^-)/l	μg(NO_3^-)/l	μg(NH_4^+)/l	mg(O_2)/l	μg(Cl^-)/l	μg(P)/l	mg/l
Method label		KM	PM	PM	VM	SFM	SFM	SFM	SFM	SFM	VM	ICPMS	ICPMS	GM
Lab. Code	mark													
00732	I15	26	5,4	54,4	24	<2	64904	<10	<1000	734	8,9	<1000	229,9	16,1
00769	I16	11	4,5	129,9	10	<2	42639	<10	<1000	97	5,5	<1000	195,2	8,65
00775	I25	339	3,5	193,4	10	<2	85904	39	<1000	197	6,7	<1000	<1000	8,0
00792	I33	76	8,3	178,4	232	<2	111485	<10	<1000	135	2,2	1432	279,4	9,45
00727	IF1	606	6,2	-19	100	<2	36282	<10	<1000	713	6,5	1400	271,5	29,65
00728	IF2	631	7,77	-66	232	<2	75957	<10	<1000	47	4,2	<1000	250,1	14,5
00729	IF3	323	7,2	-36	120	<2	25218	<10	<1000	734	4,2	<1000	271,3	23,3
00730	B1	40	5,7	50,3	32	<2	77512	15	<1000	68	3,3	<1000	259,2	10,65
00731	B17	29	5,2	60,8	28	<2	53904	18	<1000	621	3,5	<1000	249,3	8,6
00753	G1	495	4,3	143,1	8	<2	91880	<10	<1000	713	6,5	<1000	237,6	29,5
00754	G2	417	7,3	-45,7	70	<2	42307	<10	<1000	47	6,1	<1000	238,9	7,7
00755	G3	168	5,9	46	32	<2	89740	<10	<1000	734	7,0	<1000	232,8	9,6
00756	G4	654	7,6	-59,2	276	<2	53853	<10	<1000	68	4,8	<1000	233,6	9,6
00768	G5	208	7	-20	52	<2	72057	2323	<1000	128	5,8	<1000	232,6	8,45
00757	G6	2356	7,9	-65,3	304	<2	242405	<10	<1000	621	3,6	<1000	224,4	6,8
00794	GW02	39	6,8	156,7	24	<2	24807	<10	<1000	57	6,9	<1000	222,4	/
00770	GW03	339	7,9	-66,5	108	<2	26666	<10	<1000	383	3,3	<1000	214,5	8,7
00733	K001	946	7,4	-44,5	260	<2	27084	22	3627	135	6,0	1624	211,0	21,6

Note: Meaning of abbreviations for applied methods: **KM-**conductometry, **PM-**potentiometry, **VM-**volumetry, **SFM-**spectrophotometry**, GM-**gravimetry, **ICPMS**-mass spectrometry with inductively coupled plasma.
The analyses shown in Tables 5 and 6 were made at UGD-Shtip.

The water quality results from Plavica were compared with the International Finance Corporation guidelines on mining wastewater and surface water emissions (IFC 20071), which give guidelines to be achieved for the flow and leakage of wastewater into surface waters, as well as with the drinking water quality standards of the World Health Organization (WHO).

As can be seen from Tables 5 and 6 in all the analyses made from 2017 to 2024 there are increased concentrations of heavy and toxic metals. The increased contents of aluminum, iron, copper, cadmium, lead, arsenic, manganese, mercury, zinc, barium, silver, strontium, etc., deserve special attention. even before the start of mining activities. No matter what time of the year the analyses were made, an increased presence of these heavy metals was observed, as well as an acidic pH value was observed in the water samples SW1, SW2, SW3, SW10 and G1.

CONCLUSION

Water monitoring is of great importance for the continuous monitoring of the quality of groundwater and surface water, which has a significant impact on human health and environmental protection. By regularly monitoring the physical, chemical and microbiological characteristics of water, possible impacts of water on the quality of the surrounding environment can be identified. This monitoring system not only enables early detection of potential pollutants, but also supports sustainable management of water resources.

The groundwater level is very variable and ranges from 1.80 to 49.89 m. The biggest difference in the measured values of NPV variation is in the borehole IF1 and it is 14.80 m. while the smallest is in GW01 and it is 0.80 m. while the average ranges from 2.5-4 m.

Microbiological analyses of water, which are included in the monitoring aspect, help in the identification of pathogenic microorganisms that can affect human and animal health.

From the large number of analyses made, we can conclude that there is a presence of heavy metals iron, copper, cadmium, lead, arsenic, mercury and zinc even before mining activities begin.

The waters circulating through the heavily mineralized or ore parts dissolve the minerals and are highly mineralized and acidic in pH. Acidic waters are associated with mineralized parts of the concession area, while neutral and slightly alkaline waters are associated with unmineralized volcanic rocks. Monitoring water quality control sites SW1, SW2, SW3, and SW10 surface water, as well as monitoring groundwater control sites B1 and I-16, show pH acidic waters with high metal content.

The constant monitoring of water quality gives a realistic picture of the state of water resources, and therefore, it is necessary to continue monitoring in the coming period.

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