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HEAVY METALS IN SEDIMENTS AND SOILS AROUND THE BUČIM COPPER MINE AREA

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A b s t r a c t: In frame of this paper are given the results and findings from the research performed for determination of metal pollution around the porphyry copper deposit Bučim. After the analysis and interpretation of data were confirmed the assumptions for increased values of the the following metals: Cu, Fe, Zn, Pb, Mn, Ni, Cd, Ag, As and Co. Since the Bučim Mine is a mine for copper exploatation, especially interesting were the results for Cu that reached 17.5÷153541.0 mg/kg in sediments and 35.0÷4248.0 mg/kg in soils. The increase of metal concentration was determined in all of the analyzed medias: sediment and soil. Increased concentrations of metals quite often were of several times magnitude over the maximal allowed standards. The increase of metals concentration of metals in sediments and soils was highest in the area of the tailling dam and below the studied watercourses.

Key words: pollution; metals; copper; mine; sediment; soil

INTRODUCTION

Impacts of mining upon the environment are many and various. They range from factors such as the disturbance and removal of habitat, to the deposition of large spoil heaps of waste material. This study was aimed to look at the Bučim mining area in Macedonia and the associated chemistry of sediments and soils around the local rivers associated with mining activities.

The lack of pollution controls, mining activities together with increased industrial waste discharge and other pollutants emission in the broader region of the Bučim copper mine area have caused significant impacts on water, sediments and soil. The first efforts to define the environmental situation was done by Fairall (2002), Serafimovski et al. (2004), Alderton et al. (2005), Boev & Lepitkova (2005) and others. Mining and milling operations together with grinding concentrating ore and disposal of tailings provide obvious sources of contamination (Adriano, 1986). Elevated concentrations of heavy metals and trace elements can be found in and around abandoned and active mines due to discharge and dispersion of mine waste materials into nearly waters, sediments and soils (Dolenec et al., 2005). Scince studies that evaluate heavy metal concentration around the active and abandoned mines in the Republic of Macedonia are scarce we have decided to perform this study and to provide a contribution to a database of heavy metal contamination, which will serve as a basis for further scientific and applicative studies.

STUDY AREA

Bučim is a porphyry copper deposit. In the Bučim ore field there is good zonality of elements and minerals. There are some small ore veins of lead-zinc mineralization where galena predomi-

nantly is concentrated in the marginal areas of the ore field. It mines copper. In the past gold has been mined from the Bučim deposit and in the 1980's when copper prices fell dramatically the mining of gold enabled the mine to stay open. Porphyry copper deposits are usually large, low grade deposits. They are generally only economic if a large amount of the ore can be mined relatively cheaply. Bučim is made more profitable with the extraction of gold from the area, which is frequently associated with copper as they behave similarly under certain conditions. The mine at Bučim has been in operation for 22 years and the estimated reserves are 100,000,000 tonnes of ore. The main drainage system of the area consists of Topolnička and Madenska River. The drainage area covers the mine and the ore processing facilities. All drainage occurs by gravity across the site. These rivers drains the S-SE and S-SW part of the mining area (around 150 km^2) and its contamination by heavy metals was expected to be increased. The sampling programme was realized from and along these rivers (Figure 1) in the year of 2002. In the year of 2005 the same watercourse was subject of detailed sampling programe, too.

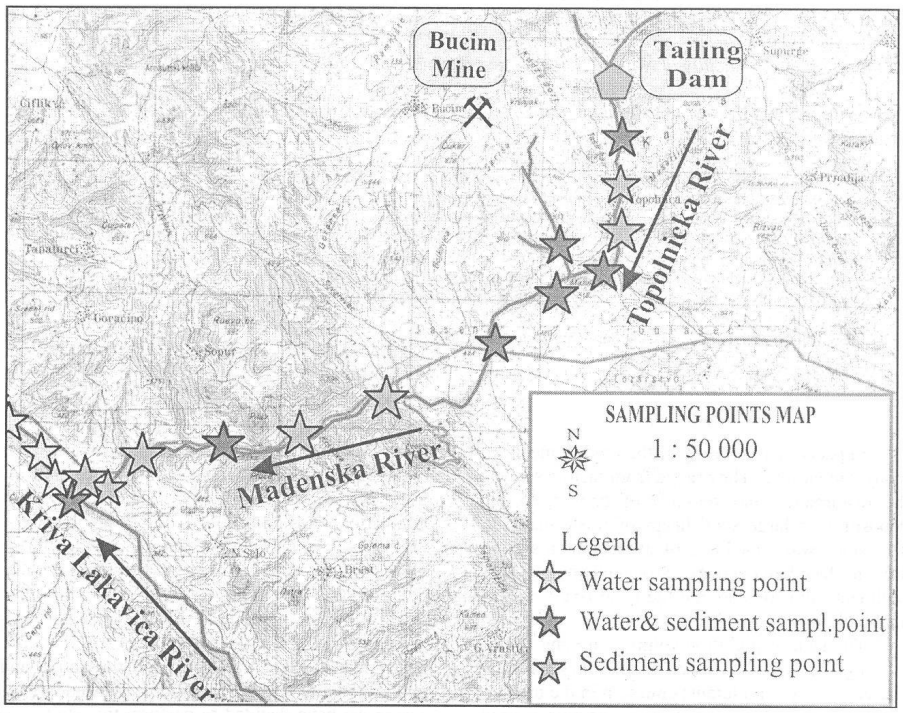

Fig. 1. Position of Bučim Mine, tailing dam and sampling points during the study in 2002 and 2005

The deposit occupies the northern parts of the Bučim–Damjan–Borov Dol mineralized area. This deposit is a copper porphyry type deposit. Ore bodies are ring-like in plan and are mainly located around the magmatic bodies and sometimes within the magmatic ore bodies themselves. Copper mineralization is related to Tertiary volcanic intrusions of andesite. The mine has been in operation for 25 years, has estimated reserves of $10 \cdot 10^6$ tonnes, and will support mining for next 20 years. Annual production was 4 000 000 tonnes of raw ore. The ore consists of 0.3% Cu, 0.6 ppm of Au, 1.1 ppm of Ag, 1.3 ppm of Mo and 1–4 % of pyrite.

MATERIALS AND METHODS

For the purpose of this study were collected 20 sediment and 24 soil samples from sampling sites shown on Figure 1. Near surface (0–20 cm) soil samples were collected because in general was not possible to distinguish A, B and C horizon. These samples were taken using plastic spatula (Fig. 2). Both, soil and sediment samples were air dried at 20°C for a week and sieved through 2 mm sieve to remove plant debris, pebbles and stones. They were then ground in a mechanical agate grinder to a fine powder for further geochemical analyses.

All the analyses were performed both on ICP-AES (*Faculty of Mining and Geology, Štip*) and ICP-MS (*Royal Holloway, University of London, UK*). The accuracy and precision were better than ±5 %. This was indicated by the results of duplicate measurements. It is very important to point out that there is chronology in sampling and analysis of the area of interest. Namely, area of interest was sampled three times in a row in 2002, 2004 and 2005.

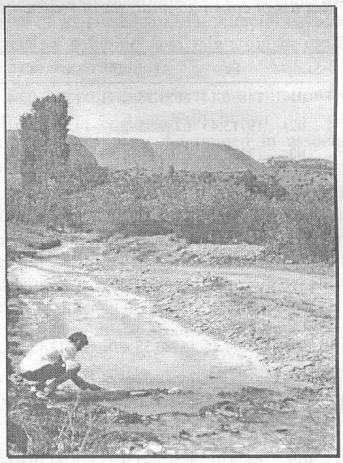

Fig. 2. Sampling of sediments from Bučim Mine drainage (year 2002)

RESULTS AND DISCUSSION

The results are given by certain river flows and adjacent area. This was done with a reason to clarify the contamination going along from near the mine and further. Since we have obtained the results from analyses we have proceeded to their interpretation, calculation of correlation factors, construction of particular diagrams etc.

Sediment samples

Similar to the water sampling and analysis programme in the area of interest was performed programme of sampling and analysis of sediments along the Topolnička and Madenska River watercourses. The results are given below in Table 1 and Table 2, chronologically 2002 and 2005.

As a summary from the analysis of sediments taken along the watercourses of the Topolnička and Madenska River, including both programme, we would like to point out the following facts:

Al – increased concentrations of this element (over MAC – maximal allowed concentrations) are present all over the sampled area, but espacially high values were determined from the second hot spot and below. Maximum values were determined in samples where the measured pH of the medium was 5.07 (deposition of Al is between pH 4.6 – 8.2) which was an ideal environment for the deposition of this element in the sediment.

Fe – in alll samples shows increased values over the MAC, while the peaks are around the two major hot spots and especially near the Pilav Tepe hill. This was caused by iron's presence in the minerals association and pH of the medium. We know that iron is deposited with an increase of alkalinity. Measured pH of 7.18 is a confirmation the fact mentioned above.

Mn – in all samples is present with an increased concentrations above the MAC.

Cu – in all the samples were determined anomalously increased concentrations of Cu in comparison with the MAC. This results from the presence of Cu as a major element in the mineral association in the Bučim Mine. Its deposition was initiated by decrease of pH of the solution (confirmed along the watercourse of the Madenska River).

Except pH as reducing agents of Cu there are the elements of the Shurmann's line, which are on the right from the Cu (Zn, Fe and rarely Pb).

Sr – in all samples is in low concentrations except in one sample where the concentration is over the standard value.

Table 1

Results of chemical analyses of sediments taken from the Topolnička and Madenska River (mg/kg), year 2002

Sample	Fe	Al	Cd	Co	Cr	Cu	Mn	Ni	Pb	Zn	As	Mo	Ag	U
d1	14896.14	6621.25	1.71	11.00	19.84	72.08	455.61	10.39	8.50	24.61	11.02	1.01	0.23	1.77
d2	19715.43	6239.95	2.57	14.30	22.02	127.20	418.58	12.93	9.81	26.32	39.49	2.99	0.29	2.35
d3	12233.76	2588.80	1.50	9.24	9.59	111.30	371.93	6.57	9.37	14.12	37.39	4.05	0.27	1.98
d4	19521.29	16927.64	2.35	10.05	26.30	2741.16	339.97	11.73	39.24	33.24	29.75	23.68	1.23	33.10
d5	7201.11	2475.09	0.86	4.18	9.16	157.94	428.43	4.24	6.10	11.56	5.50	2.35	0.23	1.53
d6	23724.33	18471.20	2.78	33.44	27.25	14107.54	3411.59	19.50	44.25	66.13	43.10	32.46	0.78	101.93
d7	9209.76	25065.46	0.03	12.98	10.90	43476.96	541.21	13.78	65.84	86.88	21.95	14.77	0.29	213.65
d8	9070.85	61916.18	0.03	55.44	12.57	147381.34	772.11	52.44	159.36	401.96	19.60	24.81	0.60	590.01
d9	8936.13	4417.88	0.03	27.28	7.85	6305.94	710.05	19.93	21.15	51.15	17.76	4.99	0.20	21.20
d10	10194.45	55583.33	0.03	137.72	13.52	152843.52	1258.11	114.27	172.66	760.13	25.45	18.81	0.89	527.82
d11	7632.45	54421.49	0.03	172.04	10.03	153541.00	1534.81	127.41	158.05	889.60	22.94	15.20	0.51	574.94
d12	9828.00	5966.58	1.07	7.26	19.18	69.96	385.20	24.80	12.86	29.53	1.75	0.21	0.06	1.76
d13	13814.64	44177.73	0.03	126.06	18.09	72727.66	1154.53	105.58	136.47	592.78	17.74	10.97	0.79	297.41
d14	8450.61	42904.24	0.03	173.80	10.03	77001.58	1587.02	124.23	125.57	629.80	16.03	10.86	0.41	348.83

Table 2

Results of chemical analyses of sediments taken from the Topolnička and Madenska River, year 2005

%	Ms1	Ms2	Ms3	Ms4	Ms5	Ms6	Ms7	Ms8	Ms9	Ms10	Ms11	Ms12	MAC
Al	1,42	1,52	1,78	1,58	3,71	2,38	2,15	2,23	3,57	5,04	2,59	9,98	0,25
Fe	5,45	2,91	3,55	3,30	4,05	3,98	3,52	5,42	5,23	3,30	14,54	2,21	1,40
Ca	0,750	0,558	0,800	0,754	0,355	1,092	0,528	0,524	0,451	0,934	3,227	0,857	
Mg	0,810	0,515	0,775	0,853	1,35	1,035	0,919	1,44	2,02	1,47	1,97	1,03	
Na	0,044	0,053	0,047	0,071	0,050	0,071	0,035	0,040	0,050	0,084	0,040	0,114	
K	0,397	0,429	0,429	0,410	0,782	0,447	0,325	0,300	0,491	0,525	0,338	0,548	
Mn	0,051	0,047	0,075	0,094	0,049	0,058	0,055	0,155	0,289	0,142	0,089	0,132	0.04
Ti	0,098	0,104	0,105	0,097	0,099	0,093	0,092	0,087	0,128	0,057	0,093	0,051	
P	0,097	0,081	0,095	0,082	0,105	0,094	0,113	0,083	0,055	0,052	0,049	0,011	
mg/kg													
Cu	211,9	103,33	381,32	755,53	1957	1750	5299	12158	25018	48835	2014	99798	17,5
Sr	8,94	13,54	15,48	14,77	18,15	22,95	19,33	15,12	19,72	38,52	100,75	43,99	49,00
Ba	45,23	49,45	171,51	75,10	97,40	81,38	57,53	51,28	107,51	108,59	135,81	95,51	0,70
Ni	22,24	15,75	20,35	19,51	25,07	18,33	23,19	49,97	95,83	81,79	102,12	115,25	9,90
Cr	51,32	40,85	47,95	41,72	54,05	51,59	42,81	55,35	75,25	53,79	85,55	38,04	10,0
Zn	43,05	47,75	53,59	50,94	55,33	53,00	58,07	90,92	133,54	279,85	75,55	552,97	22,5
Pb	15,57	10,97	17,59	18,21	39,85	18,57	54,27	40,20	38,52	35,05	23,93	35,59	10,5
Co	25,13	13,30	15,25	14,95	15,40	15,84	21,49	58,45	58,02	57,58	19,09	92,47	10,0
Cd	7,73	3,94	4,85	4,51	5,44	5,31	4,90	7,12	5,10	4,55	3,45	3,08	0,20
V	88,05	55,02	53,10	58,82	54,00	70,00	55,00	78,00	80,00	45,00	52,00	38,00	50,0
As	47,48	1,25	4,41	2,85	4,47	3,13	5,72	48,37	11,03	9,57	3,78	5,51	1,10
Ag	0,20	0,24	0,71	0,93	0,70	0,53	0,17	0,17	0,23	0,32	0,27	0,56	0,5

Ni – this element was determined as a trace element in the Bučim's mineral association and that is way its concentrations are increased and over the standard values. Its maximum was determined where the acidity of the medium was lowest.

Cr – in all samples were determined increased values (over the standard values) of this element.

Zn – increased concentrations are result of the presence of the sphalerite in the mineral association in the Bučim Mine. The increase of concentration was followed by decrease of acidity of the medium.

Pb – all the samples show increased values over the MAC, especially in the lower part of the watercourse.

Co – the same as for Pb counts for Co, too.

Cd – this very toxic metal in all the samples show very high values and all of them are above the standard values.

V – in the mineral association is bounded to chalcopyrite and this explains the its high values. The highest values were registered just below the first hot spot.

As – it very high concentrations over the standard values were determined in all samples This is because of its presence in the mineral association and its low solubility and migration in mediums with a ceratin pH values.

Ag – mainly the highest concentrations were determined in relation with higher pH values. Maximal values were determined in association with pH 7.1.

It could be concluded that the highest distribution of heavy and toxic metals was determined in samples taken from location where Madenska River inflows into Kriva Lakavica River. This due to mixing of waters with different concentrations of metals and metaloids and different pH values. The pH values in the Madenska River were in the range 4.28÷4.88, those in Kriva Lakavica were around 7.18, while at the inflow point the pH values were 5.07 that is an ideal condition for deposition of certain elements.

After the analyses and interpretation of results we have constructed few diagrams with an intent to emphasize some of the facts determined during the interpretation of data from both programme (Figures 3, 4, 5 and 6).

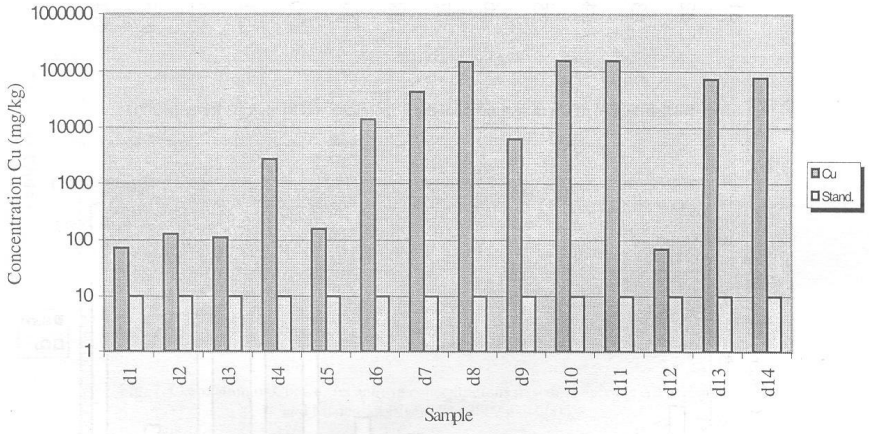

Fig. 3. Distribution of Cu in sediments of the Topolnička and Madenska River in 2002

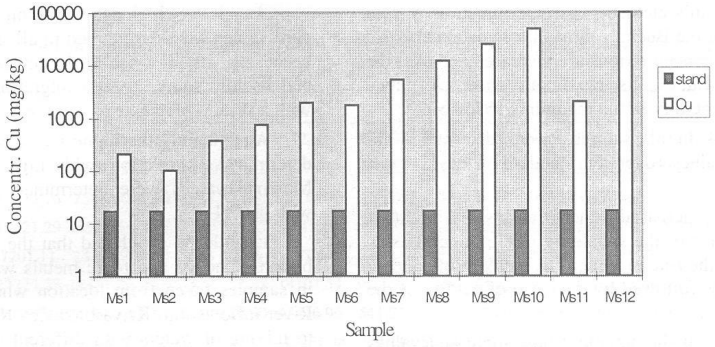

Fig. 4. Distribution of Cu in sediments of the Topolnička and Madenska River in 2005

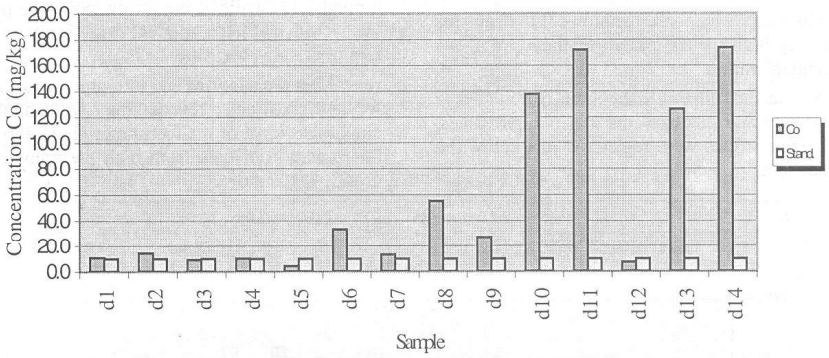

Fig. 5. Distribution of Co in sediments of the Topolnička and Madenska River in 2002

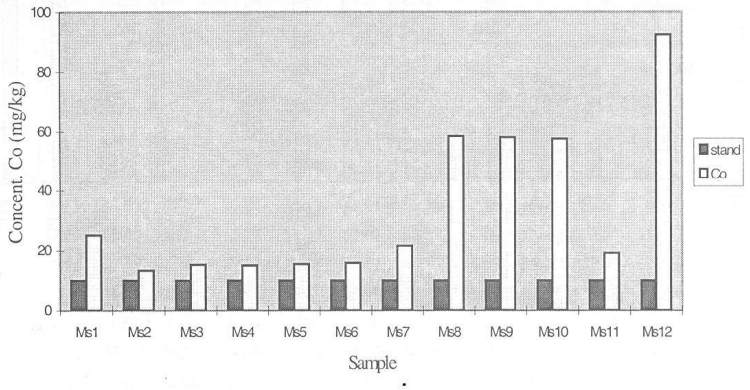

Fig. 6. Distribution of Co in sediments of the Topolnička and Madenska River in 2005

Also, we would like to show some of the correlation factors that were determined for certain metals and toxic elements in sediment samples:

Cu-Al 0.97; Cu-Ni 0.7÷0.85; Cu-Zn 0.92÷1.00; Cu-Co 0.85÷0.90; Sr-Fe 0.80; Ni-Al 0.73÷0.84; Cr-Fe 0.84÷0.88; Zn-Al 0.89÷0.97; Zn-Ni 0.70÷0.98; Co-Al 0.77÷0.83; Co-Mn 0.73; Co-Ni 0.75÷0.98; Co-Zn 0.79÷0.98; V-Cd 0.81; As-Cd 0.84; Fe-Cd 0.85; Fe-As 0.66; Al-Pb 0.99; Al-Mo 0.61; Al-Ag 0.55; Al-U 0.98; Cd-Cr 0.77; Co-Pb 0.88; Co-U 0.83; Cu-Pb 0.97; Cu-U 0.99; Mn-Mo 0.67; Ni-Pb 0.89; Ni-U 0.83; Pb-Zn 0.93; Pb-Mo 0.56; Pb-Ag 0.54; Pb-U 0.97; Zn-U 0.90; As-Mo 0.55; Mo-Ag 0.80; Mo-U 0.54; etc. Some of the diagrams that were ploted concerning the correlation matter are given below (Fig. 7 and Fig. 8).

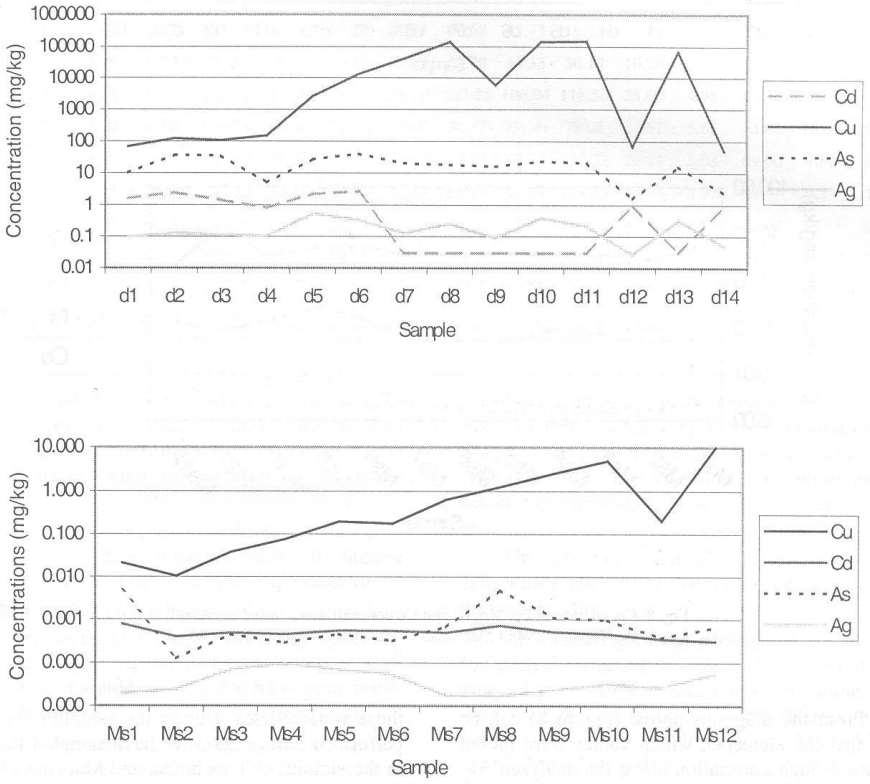

Fig. 7. Correlation of Cu, Cd, As and Ag concentrations in sediments of the Topolnička and Madenska River, data 2002 and 2005

As can be seen from the figure above, the geochemical existence of Cu, Cd, As and Ag in sediments from the watercourse of Topolnička and Madenska River almost paralel, except for Cu and Cd in lower parts of the sampled watercourse.

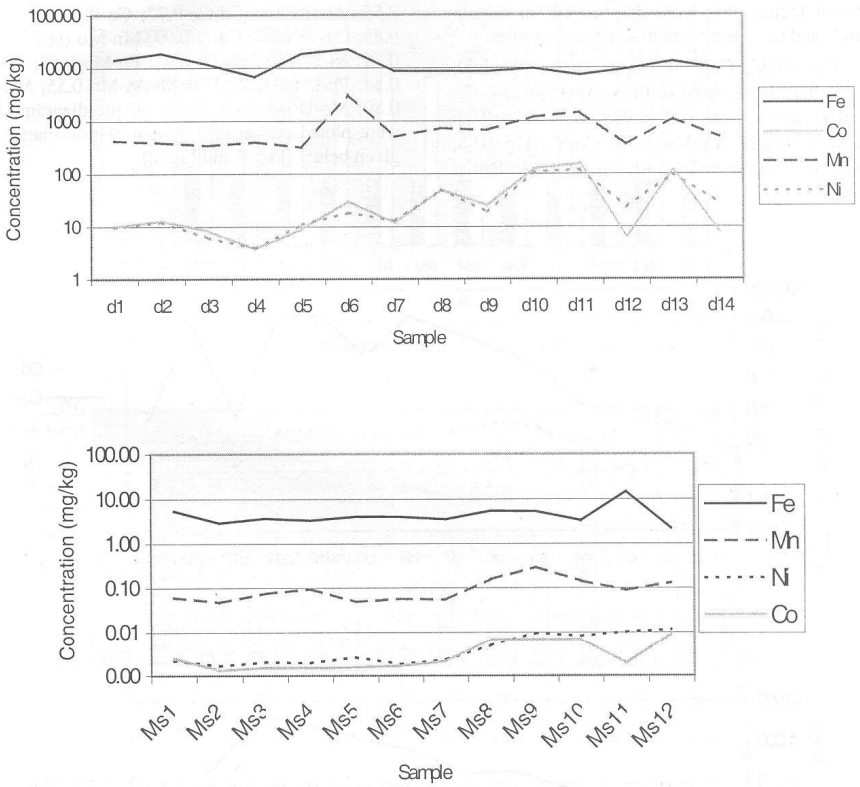

Fig. 8. Correlation of Fe, Mn, Ni and Co concentrations in sediments of the Topolnička and Madenska River, data 2002 and 2005

From the diagrams above (Figure 8) can be seen that the elements, which values were ploted on, are in high correlation along the analyzed watercourse. Decrease or increase in concentrations look like simultaneous.

Soil samples

Results from sampling programmes of water and sediments from the watercourses of Topolnička and Madenska River gave us a clue to proceed with a sampling programme of soils around those watercourses. During the sampling that was performed during 2005 we have sampled the area in the vicinity of Topolnička and Madenska River. The sampling programme was realized along profiles that were established normaly to the watercourse. Samples were taken approximatelly from 25 meters from the watercourse on both sides. After the sampling the samples followed the same procedure as it was mentioned in the Materials and methods part of the text.

The results that were obtained with an analysis of soil samples are given in Table 3.

Table 3

Results of chemical analyses of soils taken from the Topolnička and Madenska River and corresponding standards (mg/kg), year 2005

Sample	Al	Fe	Mn	Cu	Sr	Ba	Ni	Cr	Zn	Pb	Co	Cd	V	As	Ag
Mp1	2.20	4.84	0.07	35.00	20.81	244.05	25.84	55.22	87.97	8.57	19.68	6.64	79.00	3.08	0.53
Mp'1	1.94	3.59	0.06	196.79	15.75	89.66	21.06	47.24	44.08	25.31	15.19	4.84	51.00	43.95	0.38
Mp2	1.51	2.43	0.04	68.69	22.33	78.73	15.28	28.60	40.64	18.06	10.24	3.15	38.00	14.43	0.20
Mp'2	1.59	3.39	0.06	135.13	42.54	110.13	17.41	43.68	76.30	15.35	12.74	4.54	55.00	31.47	0.43
Mp3	1.82	3.00	0.04	76.80	22.15	118.05	19.92	42.06	58.78	11.78	12.97	3.93	57.00	11.68	0.42
Mp'3	2.12	3.03	0.05	72.10	22.40	124.47	22.28	45.37	73.34	25.73	12.86	4.20	54.00	1.61	0.39
Mp6	1.82	5.01	0.07	295.34	9.49	56.00	21.21	66.58	45.73	19.45	19.14	7.04	88.00	33.20	0.36
Mp'6	1.74	5.26	0.03	223.88	9.14	70.66	15.77	55.79	44.33	30.18	10.26	7.08	75.00	8.56	0.51
Mp7	2.21	3.58	0.10	212.63	41.50	109.21	360.42	203.25	106.04	118.56	25.60	4.98	45.00	16.02	0.59
Mp'7	2.26	4.10	0.18	180.58	58.00	107.21	80.89	46.47	261.41	79.08	22.67	5.65	43.00	18.59	0.42
Mp8	2.79	3.83	0.10	165.99	29.57	135.19	160.27	77.52	90.35	151.73	21.24	5.03	69.00	7.88	0.27
Mp'8	2.92	3.74	0.09	164.39	32.19	138.38	77.73	65.03	90.61	128.83	18.96	5.22	73.42	9.23	1.01
Mp9	1.79	4.98	0.16	4248.00	11.40	47.57	59.08	77.82	82.11	21.61	41.82	6.72	86.65	51.92	0.16
Mp'9	2.38	3.96	0.09	2824.00	32.67	80.11	111.50	109.54	86.57	38.64	26.15	5.30	61.04	0.70	0.46
Mp12	1.93	2.93	0.05	60.07	308.51	71.90	55.49	59.28	69.29	19.36	13.65	3.84	45.45	9.63	0.37
Mp'12	2.36	3.15	0.054	58.95	39.16	77.08	57.31	65.53	71.5	21.48	14.14	4.19	49.37	6.98	0.32

Al – concentration of Al in all soil samples was higher than the standard values, which resulted from the geological composition of the area. The highest concentration was determined in sample Mp'8.

Fe – in all samples iron showed higher concentrations than than standard values. Its highest values were determined in samples Mp'6 and Mp6.

Mn – this element have shown concentrations few times higher than those allowed by standards. It should be pointed out that these samples were sampled from arable soils treated by organic fertilizers, which increased the concentration of Mn.

Cu – copper have shown concentrations few times higher than standard values. It is a consequence of geology of the area, but mostly anthropogene factor have contributed significantly. Maximum concentration was determined in sample Mp9.

Sr – in analyzed sample wasn't determined increased presence of Sr, except in sample Mp 12 where this element exceeds the standard value.

Ba – in all samples the concentartion of this element is few times higher than the value allowed by standard.

Ni – its presence in the mineral association as trace element causes very high concentrations in analyzed samples. Beside the presence in the mineral association its very high concentrations are because of application of organic fertilizers in the area.

Cr – chromium behaviour is similar as it was case with nickel. It reaches its maximum value in the sample Mp7.

Zn – because of the geology of the area Zn has been determined in very high concentrations, especially in samples taken near the mine. Extremely high concentrations were determined in samples Mp7, Mp'7, Mp8, Mp'8, Mp9, Mp'9, Mp12, Mp'12 as a direct consequence of the anthropogenic factor.

Pb – in most of the samples its concentrations were higher than the standard values.

Co – in all samples was determined increased presence of this element, above the standard values. The maximum value was detrmined in sample Mp'9.

Cd – the very toxic cadmium showed very high values in all samples, all of them few times

above the standard values. This fact point out to a very serious contamination with this metal.

V – is present in mineral association in the area, which have been demonstrated by high concentration in soil samples. Its highest concentration has been determined in sample Mp6.

As – as a direct consequence of geology of the sampled area arsenic was determined in concentrations higher than standard values. The highest concentration of arsenic was determined in sample Mp9.

Ag – as one of major components in the Bučim Mine its presence in concentrations higher than standard values didn't surprised us. Maximum value was registered in sample Mp7.

The main reasons for increased pollution of soils in the area of interest should be the geology and composition of rocks and mineralizations, organic fertilizers used on arable soils etc., Younger et al. (2002a, b). After the analyses and interpretation of results we have constructed few diagrams with intent to emphasize some of the facts determined during the interpretation of data from both programme (Fig's 9, 10, 11).

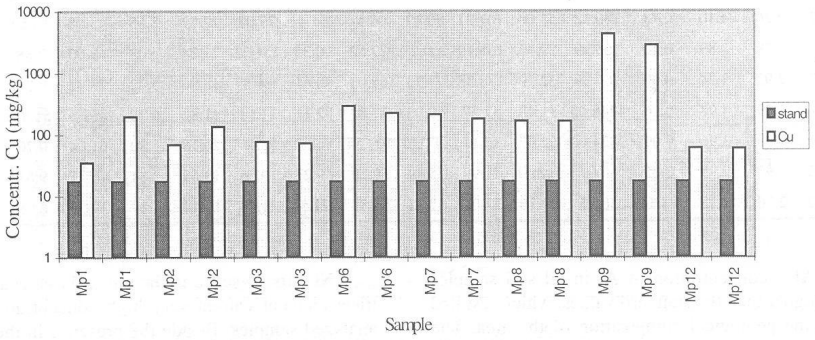

Fig. 9. Distribution of Cu in sediments of the Topolnička and Madenska River, data 2005

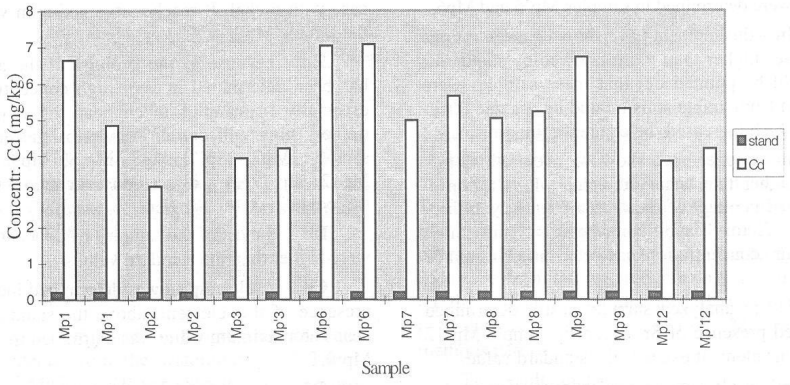

Fig. 10. Distribution of Cd in soils of the Topolnička and Madenska River, data 2005

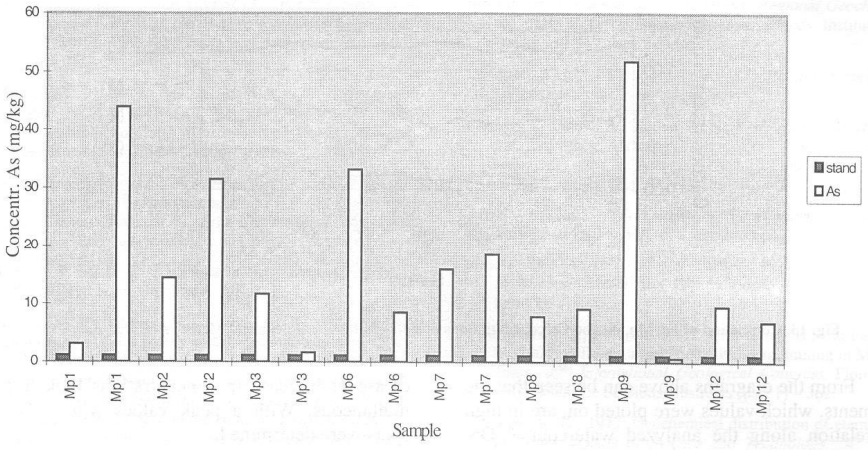

Fig. 11. Distribution of As in soils of the Topolnička and Madenska River, data 2005

From the diagrams above it can be seen the substantial increase of concentrations of Cu, Cd and As in soils that are several times higher that the values which are allowed by standards.

Also, we would like to show some of the correlation factors that were determined for certain metals and toxic elements in soils samples, in the same manner as it was done for the water and sediments: Cu-Mn 0.52; Cu-Co 0.82; Sr-Ti 0.81; Zn-Mn 0.78; Pb-Al 0.76; Co-Mn 0.82; Cd-Fe 1; V-Fe 0.82; V-Cd 0.81;.

Some of the diagrams that were ploted concerning the correlation matter are given below (Figs. 12 and 13).

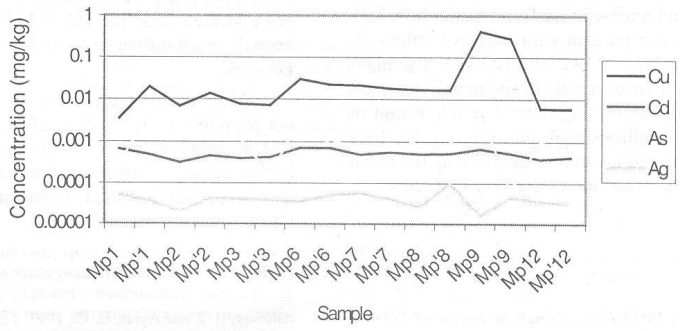

Fig. 12. Correlation of Cu, Cd, As and Ag concentrations in soils of the Topolnička and Madenska River, data 2005

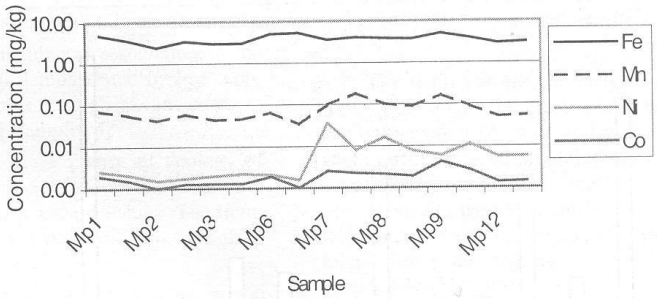

Fig. 13. Correlation of Fe, Mn, Ni and Co concentrations in soils of the Topolnička and Madenska River, data 2005

From the diagrams above can be seen that the elements, which values were ploted on, are in high correlation along the analyzed watercourse. Decrease or increase in concentrations look like simultaneous. With a peak values where the hot spots were determined.

CONCLUSION

In general, after summarizing all the facts, which have resulted from this research we could say that, due to intensive mining in the Bučim Mine during the previous years, was determined serious disturbance of the natural metal balance in medias such as sediments and soils. The analysis results of samples taken from sampling points along Topolnička River, Bučim Mine drainage, Madenska River and its inflow into Kriva Lakavica River have shown that this drainage area has been significantly contaminated by heavy metals and trace elements. The determined concentrations of metals shown increased values, no matter how high they were in comparison with maximal values allowed by standards (MAC and NOAA). The highest concentrations of metals in sediments is highest in the area of the tailling dam. The deposition of metals in the taillings took place during the long period of time and is understandable why the metal concentrations in sediments are very high there.

Increased concentrations of heavy and toxic metals are direct consequence of few factors: geological composition of the area, anthropogenic influences such as mining, miling and deposition of tailing, application of organic fertilizers on arable soils, physico-chemical features of waters (pH, Eh etc.).

During the study period were determined two major and one minor so called "hot spots". The major ones are the tailing dam near the Topolnička village while the other one is caused by drainage system from the Bučim Mine. The minor one has been located near the Pilav Tepe hill where has been detected influence from the former iron mine, Damjan.

After all the results and conclusions that came out from this analysis of the close proximity of the Bučim Mine it remains the open question the bioavailability of determined metals and metaloids and possibility of their inclusion into the food chain.

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Резиме

ЗАГАДУВАЊЕ СО ТЕШКИ МЕТАЛИ НА СЕДИМЕНТИТЕ И ПОЧВИТЕ ОКОЛУ РУДНИКОТ ЗА БАКАР БУЧИМ

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Клучни зборови: загадување; метали; бакар; рудник; седименти и почви

Во рамките на овој труд се дадени резултатите и заклучоците од истражувањата на загадувањето со метали околу порфирското бакроносно наоѓалиште Бучим. По анализата и интерпретацијата на податоците беа потврдени претпоставките за зголемени вредности на следните метали: Cu, Fe, Zn, Pb, Mn, Ni, Cd, Ag, As и Co. Бидејќи рудникот Бучим е рудник за експлоатација на бакар, од посебен интерес беа резултатите за Cu кои достигнаа вредности 17.5 ÷ 153541.0 mg/kg во седиментите и 35.0 ÷ 4248.0 mg/kg во почвата. Зголемени концентрации на металите беа утврдени во сите анализирани медиуми: седименти и почви. Зголемените концентрации на метали многу често беа неколку пати поголеми од максимално дозволените концентрации. Зголемувањето на концентрациите беше највисоко во областа на браната на јаловиштето и подолу по проучуваните водни текови.