НАУЧНО-ТЕХНИЧЕСКИ СЪЮЗ ПО МИННО ДЕЛО, ГЕОЛОГИЯ И МЕТАЛУРГИЯ
SCIENTIFIC AND TECHNICAL UNION OF MINING, GEOLOGY AND METALLURGY
НАУЧНО-ТЕХНИЧЕСКИЙ СОЮЗ ПО ГОРНОМУ ДЕЛУ, ГЕОЛОГИИ И МЕТАЛЛУРГИИ

PROCEEDINGS

OF THE XI-TH NATIONAL CONFERENCE WITH INTERNATIONAL PARTICIPATION OF THE OPEN AND UNDERWATER MINING OF MINERALS

June 19-23, 2011
International House of Scientists "Fr. J. Curie"
Varna, Bulgaria

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1. **Contemporary technologies, systems and methods in open cast quarrying of coal, ore, industri raw materials, ornamental rocks and building materials. Mineral processing and recycling.**
2. **Drilling and blasting technique, transport and work safety. Ventilation of the deep opencas mines.**
3. **Information technologies, computer systems, software products in geological prospecting, mi surveying and mining activity.**
4. **New machines and equipments – drilling, excavator, means of transport, spoil and recultivatio machinery. Methods and devices for electrification and automation facilities of the processe Repair activities.**
5. **Draining, stability and consolidation of slopes in opencast mines and quarries. Quarries was dumps and tailings pools.**
6. **Ecological monitoring. Recycling and waste utilization. Reclamation of broken lands.**
7. **Economy, organization and management of the technological processes and production wor in the open and underwater mining of minerals. Markets and realization of the products.**
8. **The mining legislation and his harmonization with European normative base. Educati qualification and specialization of mining experts of opencast and underwater mining minerals.**

Proceedings of the XI-th NATIONAL CONFERENCE WITH INTERNATIONAL PARTICIPATION
OF THE OPEN AND UNDERWATER MINING OF MINERALS
19–23 JUNE 2011, VARNA, BULGARIA

HEAVY METALS IN THE SURROUNDING WATER AND SEDIMENTS OF TAILING DAM OF SASA MINE

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ABSTRACT

The paper shows the test results of the quality of the water and the sediments, from the Sasa mine, along the rivers Kamenichka and Bregalnica all the way to their inflows into the river Vardar. The results of the investigation showed high concentrations of certain heavy metals (Mn, Zn, Cd, Pb and Cu) in the water and the sediments that pass or derived from the vicinity of the Sasa mine. It is found that these metals are in the highest concentrations near tailing dam of Sasa mine. The concentration of these metals is significantly reduced at the inflow into the lake Kalimanci while at the outflow of the lake the water and the sediments are a clearer.

***Key words**: heavy metals, water, sediments, tailing dam*

Introduction

The impact of mining on the environment occurs in almost all stages of the mining: preparation of the field, extraction, separation and ore processing, drainage that is taken to allow mining operations and discharge of polluted waters from tailing dams.

Even after the mining activities are finished the problem with environment pollution isn't. On the contrary, this problem could last for centuries even after the closure of the mine. The problem with closed mines appears after a specified time after the cessation of operations and depletion of water from mines.

Polluted water is often acid mine drainage and horizontal shafts running through the river valleys and rivers. In acid mine drainage can be dissolved toxic metals such as copper, iron, aluminum, cadmium, arsenic, manganese, lead, zinc and mercury, which are coming from the surrounding rocks.

The most serious problem from the ecological aspect, associated with the storage of flotationslag, is release of contaminated water into surface and groundwater flows, the more complex is in the surface flows. As a result of the long time releasing of contaminated water, dangerous substances are deposited on the sides of the river - bed and around it, which leads to contamination of the surrounding soil.

Often in practice, uncontrollable situations arise and that lead to increased emission of dangerous substances in the water. Especially, dangerous is if the flotation slag flow directly in the rivers.

Analyses of water quality shows the contamination with heavy metals and according these results can be decided which methods and ways should be undertaken to improve their quality and their protection from further contamination.

The quality of surface water is under constant monitoring by the Sasa mine, and water samples are taken every 10 days from several measuring points.The results of measurements show that surface waters are detected elevated concentrations of toxic and heavy metals as a result of the impact of current activities of the Sasa mine and of historical anthropogenic impacts from acid mine drainage from old inactive holes.

Research

Drainage system in surrounding area on the mine Sasa consists of surface water of the river Crvena, river Svinja, river Kozja which flowing from field of ore deposit, and with other small mountain in fluent continue in the river Kamenichka. These rivers gravitate in lake Kalimanci.

In the Sasa mine (Pb-Zn ore), the water from the deposition lake on tailing dam No.3 – phase II (second phase) is released through the overflow collector in river Kamenichka. A small part (filtration and leaching water) are released as drainage water. Part of it is filtered into the groundwater flows. Despite all control

measures to improve the water quality of the deposition lake on tailing dam of Sasa mine (clarify with more days staying, return line for water), sometimes is possible releasing of contaminated waters.

The quality of the overflow and drainage waters is subject to the control measurements including determination of their physical - mechanical purity (solid residue), toxic chemical elements and pH value. Maximum allowable concentrations of heavy metals for water of III category in R. of Macedonia are:

Table 1

Maximum allowable concentrations of heavy metals for water of III category

Chemical element	mg/l
Pb	0,1
Zn	1,0
Cu	0,1
Cd	0,01
Mn	1
Fe	1
As	0,05
Cr	0,1
Co	2

Sediments were examined and compared with the recommended maximum permissible concentrations of heavy metals in soil and sediments in Republic of Macedonia, critical results were compared with the intervention values for maximum permissible concentrations of heavy metals according to the standards in the Netherlands.

Table 2

Maximum permissible concentrations of heavy metals in sediments and soil

Chemical element	Netherland reference / intervention mg/kg	R. of Macedonia mg/kg
As	29 / 55	30
Cd	0,8 / 12	3
Co	20 / 240	50
Cr	100 / 380	100
Cu	36 / 190	100
Ni	35 / 210	70
Pb	85 / 530	100
Zn	140 / 720	200

The purpose of this paper is evaluation of water and sediments quality in the vicinity of the Sasa mine, according to the concentration of heavy metals and to determine adverse impact on mine and tailing dam on the environment.

For this, series of activitieswere performed:

– Preparation of topographic map;

– Twenty samples of water were taken in the area of Sasa mine, along the rivers Bregalnica and Kamenichka, until the river Bregalnica flows into the river Vardar. Specifically, 3 samples over tailing dam system along the confluents of the river Kamenichka, 5 samples along the river Kamenichka (evenly

distributed to the inflow into the lake Kalimanci), 2 samples in the lake Kalimanci and 10 samples along the river Bregalnica (from the village Istibanja to the village Ubogo). These samples are marked on a map with markings from 1 to 20 (Figure 1);

– Sixteen samples of sediments were taken in the area of Sasa mine, along the rivers Bregalnica and Kamenichka, until the river Bregalnica flows into the river Vardar. Specifically, 4 samples along the river Kamenichka (evenly distributed to the inflow into the lake Kalimanci), 2 samples in the lake Kalimanci and 10 samples along the river Bregalnica (from the village Istibanja to the village Ubogo). These samples are marked on the map with markings from 5 to 20 (Figure 1);

– Preparation of samples for analysis and

– Analysis of heavy and toxic metals on collected samples (Pb, Zn, Cd, As, Cr, Fe, Mn, Cu) using the methods of ICP-AES, ICP-MS.

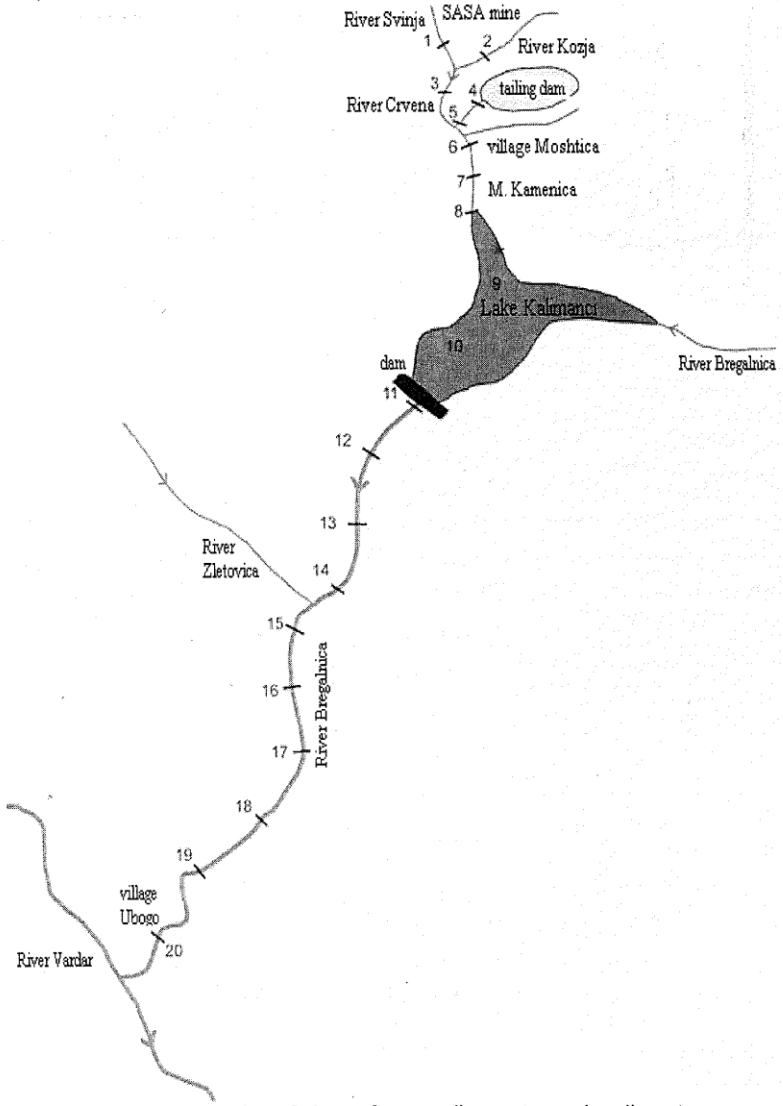

Figure 1. Representation of places for sampling water and sediments

Results

The results of water quality according measuring points (shown in Fig. 1)are shown in Fig. 2, 3, 4, 5 and 6.On the same figures are shown the measurement data in 2004/2005 (the period when Sasa mine was not working).

The measured values for the content of Fe, Cr, Co and As were below the maximum allowed concentration and aren't shown graphically.

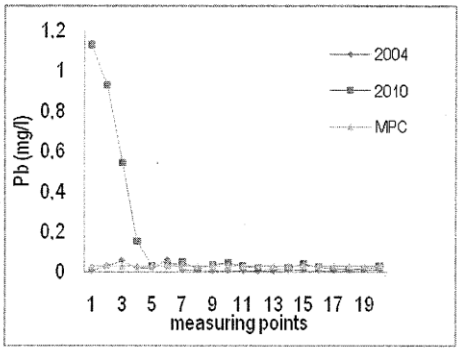

Figure 2.Concentration of Pb

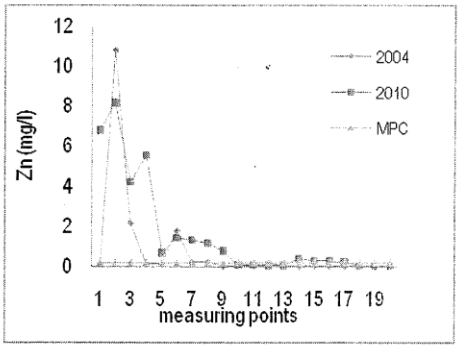

Figure 3. Concentration of Zn

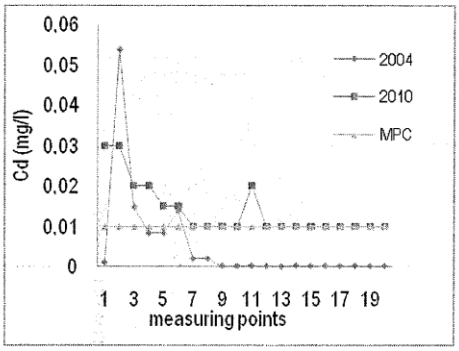

Figure 4. Concentration of Cd

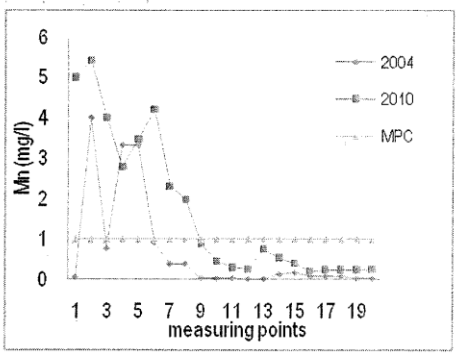

Figure 5. Concentration of Mn

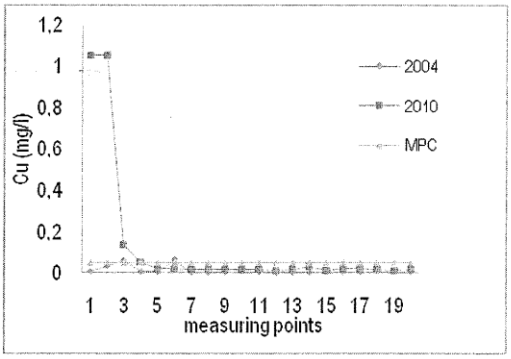

Figure 6. Concentration of Cu

The results of sediments quality taken from the same measuring points are shownin Fig.7, 8, 9,10, 11 and 12. The Figure 11 shows the results for the Mn content for measurements made in 2010 only, because such data for the 2004/2005 will not.

The measured values for the content of Fe, Cr, Co and Ni were below the maximum permitted concentration and aren't shown graphically.

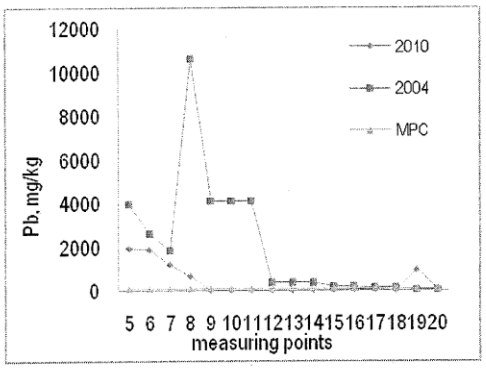

Figure 7.Concentration of Pb .

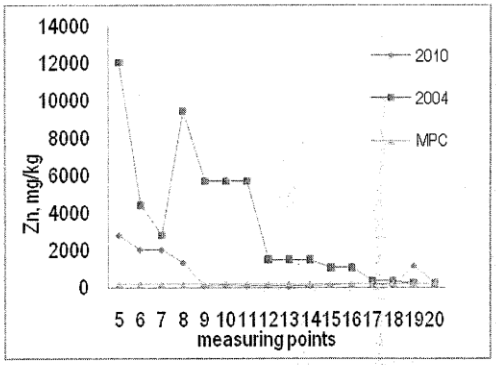

Figure 8. Concentration of Zn

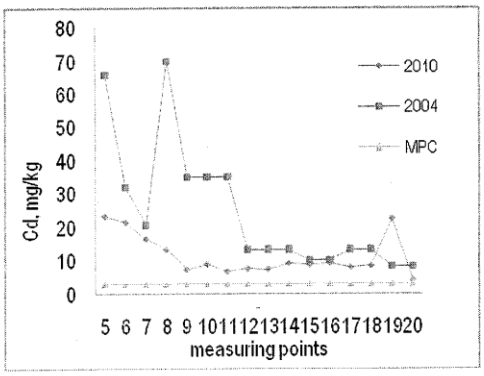

Figure 9.Concentration of Cd

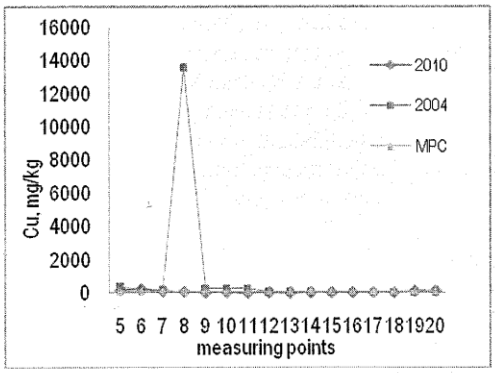

Figure 10. Concentration of Cu

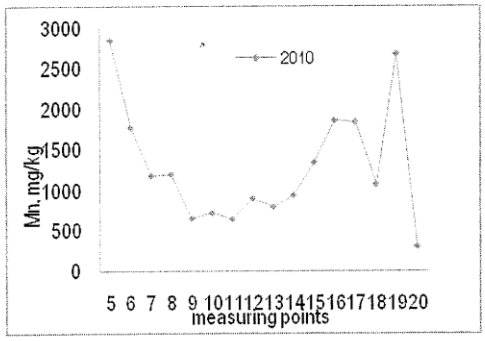

Figure 11.Concentration of Mn

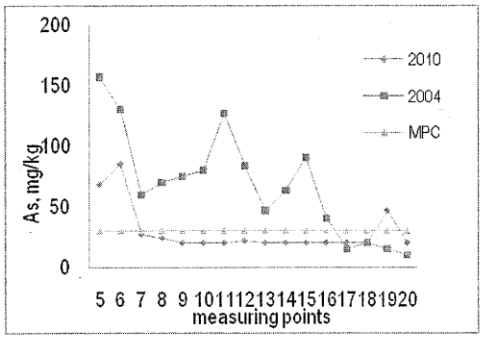

Figure 12. Concentration of As

Conclusion

The quality of the tested samples of water that pass or derived from the vicinity of the mine Sasa have high concentrations of certain heavy metals that are present in the ore and tailing dam. This primarily refers to the concentration of manganese, zinc, lead, cadmium and copper.

These metals are mostly present in samples taken at measuring points 1 - 5. The samples (1 - 3) are taken from waters that pass through terrain where once there was mining activity, and samples (4 and 5) from water in the vicinity of the tailing dam until village Moshtica.

In this area the concentration of cadmium ranged from 0,02 mg/l to 0,03 mg/l, the permissible maximum value is 0,01 mg/l. The maximum permissible valuefor lead is 0,03 mg/l, while in this area it ranges from 0,05 mg/l to 1,15 mg/l. The value for zinc is also larger and ranges from 2,6 mg/l to 8,45 mg/l, the MPC is 0,2 mg/l. The same happens with manganese, which ranges from 3 mg/l to 5,9 mg/l, a MPC is 1 mg/l. Copper ranged from 0,05 mg/l to 1,05 mg/l, and the MPC is 0,05 mg/l. Toward the inflow into the lake Kalimanci concentration of these metals are reduced, and the outflow from the lake it is almost clean water.

Along the river Bregalnica to the village Ubogo (inflow in the river Vardar), water can be classified even in class II. The exception is in the vicinity of Shtip, from village Chiflik, to village Dobroshani, where increased concentration of zinc appears again. It is periodically because the higher concentration of zinc in this area appeared only during the first sampling, while the second time has been reported fairly clean water in this area.

The fact that water is very polluted to the inflow into the lake Kalimanci, and further along the river Bregalnica continues as cleaner water indicates that as a result of the water staying, heavy metals are deposited.

Comparing the obtained results and the concentrations measured in 2004/2005 (the period when Sasa mine was not working), a difference in the concentration of heavy metals can be seen, specifically, the increased concentration measurements in 2010 as a result of active work on mine.

According to the results obtained from analyses of sediments can be seen that cadmium in all tested samples exceed the recommended maximum allowable concentration of 3 mg/kg. And intervention exceeds the maximum permissible concentration (in Netherlands) of 12 mg/kg in the upper stream of the river Kamenichka where reaches up to 26 mg/kg.This is expected because of the presence of cadmium in tailing dam of Sasa mine. In the area of lake Kalimanci, to the estuary in the river Vardar concentration of cadmium is an average of about 8 mg/kg.

From the results of the concentration of cobalt, chromium and nickel, can be concluded that within the recommended MPC, while arsenic, copper, lead and zinc occur deviations from the recommended MPC in upper stream of river Kamenichka and a small part downstream of the river Bregalnica.

From this we can conclude that sediments from the tailing dam to inflow into the lake Kalimanci are very polluted and the concentration of As, Cd, Cu, Pb and Zn exceed even the intervention standard values from Netherland. Sediments from the lake Kalimanci to inflow into the river Vardar are not so polluted, and in some areas where we exceeded the recommended MPC, there are not exceeding intervention standard values from Netherland.

The concentration of heavy metals in the sediments examined in 2004/2005 is significantly higher compared with measurements made in 2010 as a result of the accident of tailing dam which occurred in 2003.

By this time are introduced some ISO standards in Sasa mine, including Standard for environmental management - ISO 14001. Using this standard, care for the environment will be performed. Up to the present time, problems are solved in a good direction, although there are still risks and possible unexpected cases that may make unnecessary problems to the environment.

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