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SOURCES OF POLLUTION IN LEAD - ZINC CONCENTRATE PRODUCTION IN THE FLOTATION PLANT "KOPAONIK" – LEPOSAVIĆ

Abstract

The aim of this paper is to monitor the operation of the Flotation Plant Kopaonik - Leposavić, where the technological process of flotation of lead - zink ore is carried out, with special reference to the sources of pollution created during in the given technological process. The pollution caused by the technological process of lead-zinc ore flotation in the Flotation Plant "Kopaonik" Leposavić can be divided into three groups: water pollution, soil pollution and air pollution. This work wants to emphasize the importance of mining production sustainable development in near future, strengthening of ecological awareness, development of ecological volunteer activities and implementation of more and more stringent environmental standards. The constant increase in the cost of protection to date is a consequence of continuous improvements of both legal regulations and general ecological awareness.

Keywords: *concentrate, exploitation, pollution, regulation*

1 INTRODUCTION

The Flotation Plant is located in Leposavić, which, together with the mines Crnac, Belo Brdo, Žuta Prlina and Koporić, composes the working organization Kopaonik within the Trepča combine.

The mines Belo Brdo, Žuta Prlina and Koporić were opened in the places with the same names on the slopes of the Kopaonik mountain, on the right bank of the Ibar River. The Crnac mine was opened in the place carrying the same name on the Rogozna mountain on the left bank of the Ibar River. The traces of the mining carried out in the past are still visible in all these locations. A well-preserved branch of the old city water pipeline was found in the village of Crnac, which talks for itself about the intensity of mining.

Not far from Leposavic, on the main road for Kosovska Mitrovica, there is a settlement called Socanica, where the remains of the ancient Roman city are located, as well as the remains of the smelter, which talks on development of mining at that time, as well as that this area is rich in ore resources. The Flotation Plant in Leposavic is located so that it can receive the entire production from all four processing mines. The Flotation Plant has a plant for the primary ore crushing from the mine Crnac, while the plants for the primary ore crushing from other mines have been built in those mines themselves. The Flotation Plant has two sections for selective flotation of lead and zinc minerals. The processing capacity is 1300 tons per day, or 27 tons per hour.

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2 ENVIRONMENTAL POLLUTION WITH LEAD AND ZINC AND HARMFUL EFFECT OF LEAD ON HUMAN BEINGS

Due to the biological effects and high levels of presence, lead is one of the most important heavy metals. In the lithosphere, it is present in a form of lead minerals, which are galenite, (RbS), and anglesite, ($RbSO_4$). The metallurgical process of lead production belongs toa group of dirtiest technologies, since dangerous substances are released during the lead production in a form of gases, dust (containing Rb, As, etc.), tailings and wastewater with high lead content, resulting in contamination of the soil, surface and underground water.

In surface and underground water, lead is found in concentrations up to 0.04 mg/l, while the maximum permissible concentration in drinking water is 0.005 mg/l [1]. Lead has the ability to accumulate in surface layers of soil, where it is predominantly organically bound. It is transported through the soil most often in the form of soluble chelate complexes.

In addition to the building sulfides, lead can be adsorbed to sulfides of other metals, and it has been shown that widespread iron sulphides, pyrite (FeS_2) and mackinawite (FeS) serve as lead, mercury, cadmium and zinc substrates. Lead is a systemic poison, which means that once it enters the body, it is transmitted through the whole body, disrupting the health of a person.

In the Earth's crust, there is about a hundred times more zinc than copper (about 0.001%). The main ores are sphalerite (ZnS) and smithsonite ($ZnCO_3$), used for zinc production. The less represented ores are: zincite (ZnO), franklinite (Zn (Fe9Mn2O4)) and vilemite (Zn2SiO4). Sphalerite always contains some cadmium (II) sulphide, so the production of cadmium is linked to the production of zinc. The total zinc content in the soil ranges from 5 to 1000 mg/kg [2].

The soil formed on the base rocks contains more zinc compared to the soil formed on the acid rocks. Low solubility in water is characteristic of carbonates, oxides and sulfides, which contributes to the low concentration of zinc in natural water (0.01-0.05 mg/l). The increased concentration of zinc in water is most often caused by the industrial pollution, from mining water that are characteristic for zinc-rich mines, which can lead to an increase in zinc concentration in water, up to 50 g/l. Due to the usage of galvanized pipes and containers in the water pipe systems, the zinc content in water is often increased. The maximum permissible content of zinc in drinking water is 3 mg/l, [1].

3 WATER POLLUTION

All mining plants and facilities, active or not, pollute the environment, especially the surrounding water courses. This pollution can be physical and chemical. The content of hazardous and harmful substances in water depends on the primary source of pollution, that is, the volume and content of hazardous and harmful substances in them.

The primary sources of water course pollution can be: surface mines, underground mines, flotation plants, separations, flotation and separation tailings, deposits of coal, ash and ore, transport systems, etc. Polluted water can be surface, underground and mine water, or processing water (waste

water). Polluted water then enters the nearby water courses.

There are other pollutants in the Ibar River Basin, and it is often a problem to define a share of mine pollution in the total scope of pollution. Also, the water tests upstream and downstream of the pollution site should be done as a control tool.

Pollution of water courses at the exploitation stage of mineral resources

At the stage of mineral resources exploitation, which involves excavation, loading, transport, unloading and disposal, the water is polluted more or less, and then is transferred to the surrounding water courses and continues to spread further to larger water courses. The pollution of water that is transferred from the mine to the natural hydrographic forms can occur due to the following reasons: separation of hazardous substances from the deposit when contacted with water; physical blurring of water courses due to small particles released into water; erosion of internal landfills; release of waste solids into water; release of oil, lubricants and other oil derivatives into water; mixing of water from the repository of waste water with running water and so on.

Pollution of water courses is characteristic for the periods of increased precipitation and snow melting when eroding activities are increased. This problem is particularly present in the landfill area, where the significant amounts of waste and tailings in the form of sand and silt go into the water, later releasing numerous substances that alter the natural mineral composition of water. It is estimated that more than 40% of heavy metals have come into the water due to the erosion processes of such landfills.

Water courses in the mining plant zone are polluted long after the end of active exploitation, unless the appropriate remediation measures are taken.

Pollution of watercourses at the preparation stage of mineral resources

As a result of the preparation of mineral resources, the organic substances (phenols, etc.) appear as pollutants in the surface watercourses. Furthermore, by drainage of water from the processes related to the preparation of mineral resources, there is a greater or lesser emergence of toxic substances (phenols, cyanides, heavy metal salts, heavy metals, etc.).

Toxic reagents, pyrite pyridines (cyanides) are still used in some flotations, and despite the introduction of closed return water systems, a part of the harmful substances reach the nearby watercourses anyway.

Tailings, associated with the preparation of mineral raw materials, are large water polluters. The flotation tailing dumps overload the soil and, in addition to violation of legislation, contaminate the surface and underground water.

The flotation tailing dump Gornji Krnjin - Leposavic is located near Leposavic settlement, right on the Ibar river bank. The tailings from the lead- zinc ore preparation plant is hydraulically driven to the tailing dump, where the solid and liquid phase of tailings is separated by sedimentation.

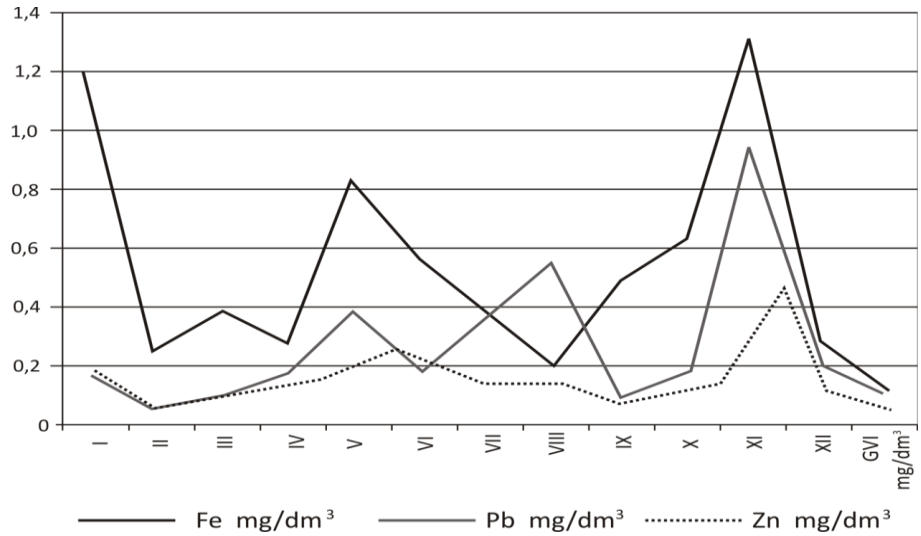
The tailing dump was active from 1970 to 1985. The surface of tailing dump is about 7 ha and about 2,600,000 tons of waste is deposited on it. The chemical composition of tailing dump is: Pb = 0.36%, Zn = 0.33% and Fe = 22%. In 1985, a new tailing dump was built in the immediate vicinity of the old one, and was named "Bostanište".

Figure 1 *Photo of the 'Bostanište' tailing dump*

The flotation tailing dump in Leposavic has a dual effect on water pollution. Firstly, the life and growth of flora and fauna in the river, in river bed, but also on the river banks, are directly affected physically and chemically by the uncontrolled deposition of flotation waste or in case of accidents. Secondly, through groundwater, the aqueous solutions from a flotation-tank lake, usually saturated with heavy metals, flow into the watercourses of the respective reception areas. The harmfulness that can be caused by devastation is acomplete destruction of the plant and animal world in the Ibar River basin, endangering objects and settlements downstream from the tailing dump and permanent contamination of soil and wells in the flooded area [2] with heavy metals.

Table 1 *Physical-chemical parameters of the Ibar downstream of Kosovska Mitrovica (mg/l) (2016).* [3]

Tested parameters	Lowest values	Highest values	Most frequent values
rN value	6,8	7,7	7,2 – 7,6
Chlorides, Sl^-	12	28	16 – 24
Ammonia	<0,02	0,3	– 0,1
Nitrite	0,1	0,9	– 0,3
Nitrates	5	<80	15 – 30
Iron	<0,01	0,9	0,1 – 0,5
Sulphates	0,02	12,6	2,8 – 5,9
Phosphates	0,0324	1,2	0,3 – 0,7
Calcium	52,6	79	55 – 69



Graph 1 *Graphical illustration of the Ibar River water quality (2016) [3]*

4 SOIL POLLUTION

Soil contamination is primarily expressed by filling the tailings (the rest of the mineral ore mixed with phase rocks) to the fertile soil, and then by penetration the remnants of reagents used in the process of ore refining. Thus, the fertile arable land becomes completely and permanently degraded, i.e. uncultivable. Furthermore, the deposit of the flotation tailings creates the industrial waste that changes the relief of soil, by its formation, whereas in the second phase, it is a source of small fractions of infertile pollutants, which cover the surrounding fields, thus turning the fertile soil into - infertile, sterile over time.

Contamination of soil near mining facilities is most often done with the help of fluids (water and air).

This means that the transport of contaminated materials is carried out with help of them, that is, they must first come into a contact with contaminated materials. [4]

The primary soil contaminants are: mining plants for exploitation, flotation and separation, deposition of tailings, mining waters, etc.

The subsidence of dust from the air is a consequence of large concentration of dust in the air created by mining operations. Dust created by blasting, moving vehicles, transportation to other areas, etc., is spread around by air movement in the vicinity of mines, and it sets down on the ground. The surface of the land has been inevitably changed in the vicinity of mines where the exploitation has been taking place for a long period of time. Flotation tailings have their negative impact on the surrounding land mainly through the water that washes away the tiny waste and deposits as sludge or sand on the surfaces in the immediate vicinity.

Also, in this case it is possible to pollute a wider environment by deposition of fine dry particles blown from the tailings by the wind. Pollution of the surrounding land can lead to reduction of yields on land in several ways, and the impact will last several years after the exploitation of tailings has ceased.

There are many heavy metals in the flotation tailings, which are not separated as a concentrate during the flotation process. The average content of these metals is different in the mixture of tailings and water in a ratio of 1:10, but it has concentration of 10 to 20 times higher than the allowed one. The penetration of this tailings into the surrounding land can result in multiple and long-term damage to the environment and the living world, including people.

During the exploitation process of mineral raw material deposits, the underground watercourses are crossed and there is an increased inflow of water into the mines. This water is collected into water collectors and taken by pumps or by gravitation out of the mine.

Table 2 *Report on the soil quality control from the Flotation Plant in Leposavic [3]Measuring location: Tailing dump*

	Tailing dump
Pb (%)	0.38
Zn (%)	0.21
Cu (%)	0.001
Cd (%)	0.0002
Fe (%)	5.02
Ca (%)	3.83
Mg (%)	2.02

Passing through the layers of ore and rocks, the water reacts chemically and becomes a solution. This is especially characteristic for mines of metal mineral raw materials where aggressive water is formed containing a lot of harmful substances. This water is sometimes taken to the watercourses, and thus they have a detrimental effect on the surrounding land..

5 AIR POLLUTION

Air pollution during preparation phase of mineral resources exploitation occurs in almost all technological phases. Somewhere this pollution is particularly visible, but frequently is difficult to notice pollution, which does not mean that it is less harmful. The most frequent air pollution occur in: drilling and mining of surface mines, operation of crushing plants, transportation of mineral raw materials and tailings, raising dust from landfill and ash dumps, oxidation on separation tailing dumps, etc.

The most important air pollutants can be divided into two groups: dust and gases. Both groups of pollutants are very present in mining.

Exploitation of mineral raw materials is carried out by destruction of massif, and fragmentation of particles to dimensions smaller than one millimeter, even microns, occurs in this process. This dust goes into the air and spreads through the air in surroundings.

The drilling phase, crushing and further shredding of the material result in a formation of potentially dangerous mineral dust. Using water when drilling partially alleviates this problem, but there are additional problems if there are clay primers in drilled rocks.

Air pollution by gas is present in the operation of diesel-powered equipment and the oxidation tailings and coal depots. Diesel equipment is mostly used in mining for the truck transportation, in the operation of auxiliary machinery and rarely, in the operation of various generators. The exhaust gases are discharged through the exhaust pipes of engine and immediately sprayed and diluted in the ambient atmosphere. The

content of hazardous components in the exhaust gases depends on the quality of diesel fuel, tfuel combustion, quality of drive engine, exhaust gas purification device, etc.

The air quality (mean values of precipitated results) in parts of the city or the surrounding area exposed to the impact of the flotation tailings is most often presented in table as shown in the attached Table 3 with data of directed measurers of atmospheric precipitation sludge, and Table 3 with data from a non-directed atmospheric sludge measurer.

Table 3 *Values of directed atmospheric precipitation sludge measurers for October 2016 [3]*

Ord. No.	Sample mark		Total solid substances mg/m^2/day	Insoluble solids mg/m^2/day	Soluble solids mg/m^2/day	Ash mg/m^2/day	Flammable substances mg/m^2/day
1.	1	E	119.92	58.39	56.53	15.01	43.38
2.		W	227.54	132.52	95.02	88.10	44.42
3.		N	146.03	87.57	58.46	45.05	42.52
4.		S	244.00	178.47	65.53	109.54	68.93
5.	2	E	142.73	78.47	64.26	48.75	29.72
6.		W	175.21	139.89	35.32	86.63	53.26
7.		N	193.87	149.54	44.35	118.23	31.31
8.		S	185.16	131.38	53.78	88.80	42.58
9.	3	E	110.72	61.78	48.94	23.36	38.42
10.		W	89.98	45.15	44.83	16.77	28.38
11.		N	133.17	79.50	54.17	30.58	48.92
12.		S	231.07	160.43	69.64	111.07	49.36

Table 4 *Values of non-directed atmospheric precipitation sludge measurers for October 2016 g.* [3]

Ord. No.	Sample mark	Total solid substances mg/m^2/day	Insoluble solids mg/m^2/day	Soluble solids mg/m^2/day	Ash mg/m^2/ day	Flammable substances mg/m^2/day	Lead concentrate µg/m^2/day	Sample quantity ml
1.	1	233.56	138.46	95.10	87.24	51.22	216.08	420
3602.	2	193.65	129.55	64.10	81.91	47.64	195.65	550
3.	3	164.84	92.75	72.09	42.42	50.33	107.39	210
MDK po St. RS		300-450					100-250	

Measuring points: 1. Flotation Plant - east of the tailing dump; 2. Gornji Krnjin - north-west of the tailing dump; 3. Kutnje - southeast of the tailing dump

CONCLUSION

It is easy to conclude that the Flotation Plant is a problem and an economic challenge for Leposavic, surrounding towns, the Ibar River, environment in general, whereas on the other hand, the Flotation Plant as a whole with the mines represents the economic security for a large number of peope living and working here.

The problem is additionally increased by the fact that the flotation equipment was already outdated at the time of construction. The lack of modern equipment and elements, both for the ore processing, as well as for the environmental protection, is manifested in a form of environment pollution and contamination by the side products of

flotation technology. The consequence of all of this is a difficult economic situation in the whole country, all the misfortunes that we have faced, and, to a great extent, the low level of awareness about environmental protection and the consequences that nature can bring back to us as a boomerang.

Whether our country joins or not the EU, the mining companies should comply with the environmental standards and appropriate environmental legislation. Thus, the population in the mining sites would be protected from the existing sources of pollution and import of dirty technologies. All this presents an additional financial burden for the company. Globally, the mining companies will themselves have to turn to cleaner technologies to relieve the ever-increasing cost of environmental protection.

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