PROCESSING OF GALENA SYNTHETIC MIXURES FOR PRODUCING LEAD AND ELEMENTAL SULFUR

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Abstract

These investigations have developed an effective hydrometallurgical method to recover high-purity lead metal and elemental sulfur from simulated galena synthetic mixures eliminating sulfur gases and lead emissions, in contrast to the current high-temperature smelting technology.

The method consists of different operations: oxidative leaching with production of solution with residue containing elemental sulfur., electrowinning by the solution with metal production.

The obtained results determined the optimal parameters for possible processing of natural domestic galena ores.

Keywords: *leaching, lead, sulfur, synthetic mixures*

Introduction

A major cost factor in the sintering and smelting process for producing Pb is the control needed to meet existing environmental standards for Pb emissions. Another issue is the current concern over acid rain, which will in all probability result in even more stringent controls on emission of sulfur gases.

Processing of the galena mixures or concentrates is developed as an effctive low-temperature leaching-electrowining method to produce Pb metal and elemental sulfur from galena mixures or concentrates. The method reduces Pb emissions and totally eliminates the formation of sulfur gases. The elemental S produced is more economical to store and ship than the sulfuric acid (H_2SO_4) generated by the high-temperature smelting process.

This hydrometallurgical method consists of leaching galena synthetic mixures or concentrates in waste fluosilicic acid (H_2SiF_6) with hydrogen peroxide (H_2O_2) and lead dioxide (PbO_2) as oxidantsat 95^o, electrowinning the ($PbSiF_6$) solution at 35^o to produce *99,99%Pb* metal, and solvent extraction to recover S, leaving a residue containing eventually present Cu, Ag, and other metal values.

$$2PbS+3H_2SiF_6+H_2O_2+ PbO_2 \Rightarrow 3PbSiF6+4H_2O+2S^o \qquad (1)$$
$$PbSiF_6+2H^++2e^- \Rightarrow Pb+ H_2SiF_6 \qquad (2)$$

Several galena leaching processes have been investigated, including processing using ferric chloride, ferric sulfate, nitric acid and ammonium acelate solutions. The leached $PbCl_2$ and $PbSO_4$ salts have a very limited solubility in aqueos solution, making aqueos electrolysis difficult. Lead metal was recoverable from $PbCl_2$ by molten-salt electrolysis operated at 450^o. It's known that elecrowinning of Pb in HNO_3 and H_2SiF_6 solutions yields Pb metal at the cathodes and at the same time PbO_2 at the anodes.

The next text will explain the oxidative leaching-electrowinning process. The parameters for leaching process about synthetic mixures were investigated in laboratory experiments.

1. General

The chemical equations for PbS leaching in acid solution with and without oxidants follow:

$$PbS+2H^++[O] \Rightarrow Pb^{2+}+S^o+H_2O \qquad (3)$$
$$PbS+8H^++8[O] \Rightarrow PbSO_4+4H_2O \qquad (4)$$
$$PbS+2H^++ \Rightarrow Pb^{2+}+H_2S \qquad (5)$$

Reaction *(3)* shows that oxidative leaching of PbS will yield Pb salt and elemental S. Reaction *(4)* suggests $PbSO_4$ may form if the redox potenial of the solution is too high, and reaction *(5)* indicates H_2S will form when leaching in acid solution if the redox potential is too low. To avoid the generation of H_2S one-fourth of the required oxidant have to be added to the H_2SiF_6 solution prior to the addition to the PbS. The reaction is exothermic and it's necessary to add H_2O_2 slowly through a birette to avoid overheating the leach solution. After adding the H_2O_2, PbO_2 was added slowly to control the redox potential. The reacions occuring during the oxidative leaching of PbS synthetic mixures or concentrates with H_2SiF_6 are shown below. At the end of leaching, the mixture was filtered to separate the leachate from the residue. The residue consisted of elemental S and other metal values. The leachate is sent to electrowinning to recover pure Pb metal.

$$PbS+H_2O_2+H_2SiF_6 \Rightarrow PbSiF_6+2H_2O+S^o \quad (6)$$

$$PbS+PbO_2+H_2SiF_6 \Rightarrow PbSiF_6+PbO+H_2O+S^o \quad (7)$$

$$PbO+H_2SiF_6 \Rightarrow PbSiF_6+H_2O \quad (8)$$

2.1 Previous investigations

As leaching parameters were investigated: *PbS* samples of 98% on the –400 mesh or 96% on the as-received concentrates if H_2O_2 and PbO_2 were used as oxidants (the possible oxidants may be air, oxygen, ozone, HNO_3 and MnO_2); leaching temperature from 50-95°; leaching time from 35-335 min. The results of carried out investigations follow:

Table 1. *Effect of various amounts of oxidants*

Test	H_2O_2 35%-ml	PbO_2 gr.	Pb%
1	0,0	16,0	92,0
2	2,5	17,0	95,0
3	5,0	9,8	95,0
4	7,5	8,1	96,8
5	10,0	5,7	95,1
6	19,0	0,0	96,0

Table 2.*Effect of time and temperature*

Leach temperature T°C	Leach time, (min)	Pb%
50	335	62,3
70	240	91,5
80	90	76,0
90	75	90,1
90	90	97,5
95	35	96,0
95	75	96,5

Table 3. *Effect of leach time in Pb extraction*

	Leach time		
	30 min	60 min	90 min
Pb%	92,3	95,6	96,4
Leachate,g/l:			
Pb...........	163,500	176,700	180,300
H_2SiF_6....	62,900	55,400	52,300
Zn...........	0,540	0,619	0,683
Fe...........	0,369	0,415	0,091
Cu..........	0,050	0,091	0,109
Co..........	0,006	0,007	0,007
Ni...........	0,012	0,014	0,007

Table 4. *Effect of H_2SiF_6 concetration*

	H_2SiF_6-technical-grade acid			
	175 g/l	200 g/l	250 g/l	300 g/l
Pb%	89,0	97,5	95,4	95,7
Leachate,g/l:				
Pb...........	180	179	184	177

H_2SiF_6....	32	56	94	133
Zn..........	0,57	0,75	0,82	1,00
Fe..........	0,53	0,61	0,61	0,67
Cu..........	0,12	0,13	0,13	0,18
Co..........	0,00	0,00	0,00,	0,00
Ni..........	0,02	0,02	0,02	0,02

The effect of using different combinations of oxidants of H_2O_2 and PbO_2 on PbS leaching was insignificant. Previous leaching experiments showed that H_2O_2 was a more efficient oxidizer to initiate the leach reaction. Also, it was less expensive than PbO_2. Thus, it is beneficial to use H_2O_2 to leach PbS and only use PbO_2 at the end of the leach to void oxidizing PbS into $PbSO_4$.

Leaching temperatures had a great influence on reaction rate and Pb extraction. When leaching below 80°C, the reaction rate was thought to be too slow for any practical pplication. Lead extraction was 96% when leaching at 95°C for 35 min using H_2O_2 and PbO_2 as oxidants. The leach-ing rate increased greatly and the required leaching time was reduced from 90 min to 35 min as the temperature increased from 90°C to 95°C. Lead extraction was increased from 92% to 96% as leaching time increased from 30 min to 60 min at 95°C. Initial leaching was rapid, but the elemental sulfur formed and coated the PbS particles, further reaction was probably diffusion controlled and the leach rate was reduced. However, the efect of the sulfur coating was not critical, because of the fine particle size of the PbS.

The amounts of PbS, PbO_2 and H_2SiF_6 used in a leach test determined the concentration of $PbSiF_6$ and free H_2SiF_6 in the pregnant leachate. Increasing the concentration of free H_2SiF_6 above 60 g/lit had no significant effect on the Pb extraction, extraction of impurities decreased with decreasing concentration of free H_2SiF_6.Lead extraction of 96%, 91% and 96% were achieved using H_2SiF_6 solutions made from technical-grade, waste, and recycled acid. Waste H_2SiF_6 contained HCl and H_2SO_4 as impurities, which formed some insoluble Pb salts during leaching, resulting in lower Pb extraction. Recycled electrolyte, in which impurities were removed during prior leaching, was as reactive as technical-grade H_2SiF_6.

1. Experimental tests

The conditions by the leaching process of the synthetic galena mixures (PbS) with gangue mineral's compounds (ZnS, CuS, NiS, CoS, CaO, MgO, Fe_2O_3, SiO_2) and oxidants addition H_2O_2 and PbO_2, leaching temperature (°C) with retaining leaching time (min) in the presence of technical H_2SiF_6 is shown on the following tables.

Table 5. *Chemistry composition of the synthetic mixures*

Compounds	Synthetic mixures (%)		
	I	**II**	**III**
Pb	50.000	60.000	
PbS	57.740	70.000	80.830
ZnS	5.000	5.000	5.000
CuS	1.000	1.000	1.000
	0.050	0.050	0.050
Fe_2O_3	1.010	1.050	1.020
SiO_2	29.200	16.900	6.100
Al_2O_3	2.000	2.000	2.000
CaO	2.000	2.000	2.000
MgO	2.000	2.000	2.000
Total	100.000	100.000	100.000

Table 6. *Effect of various amounts of oxidants*

Test *(Pb-70%)*	H_2O_2-35% ml	PbO_2, gr	Pb (%)
1	0,0	15,0	90,0
2	2,5	15,0	95,0
3	5,0	9,5	95,0
4	7,5	8,0	96,5
5	10,0	5,0	95,0
6	19,0	0	96,0

Table 7. *35% H_2O_2 (7,5 ml); PbO_2 (8 gr)*

	H_2SiF_6			
	175 gr/l	*200 gr/l*	*250 gr/l*	*300 gr/l*
Pb(%)	85,0	97,5	95,0	95,5
Analysis of leachate, gr/l				
Pb...........	180	175	185	175
H_2SiF_6.....	30	55	90	130
Zn...........	0,55	0,75	0,80	1,00
Fe...........	0,50	0,60	0,60	0,65
Ni...........	0,10	0,10	0,10	0,2
Cu...........	0,015	0,02	0,02	0,02

Table 8. *35% H_2O_2 (7,5 ml); PbO_2 (8 gr); H_2SiF_6 (200 gr/l)*

Pb%	*T^oC*	*t(min)*	*Pb%*
50%	70	30	52,5
		60	56,5
		90	65,3
	80	30	54,2
		60	58,5
		90	67,0
	90	30	56,5
		60	59,1
		90	70,0
60%	70	30	55,6
		60	60,2
		90	68,7
	80	30	57,2
		60	63,3
		90	71,5
	90	30	57,0
		60	61,0
		90	73,5
70%	70	30	60,5
		60	63,8
		90	75,0
	80	30	65,0
		60	72,0
		90	79,0
	90	30	87,6
		60	95,3
		90	97,6

Conclusions

Above mentioned combined hydrometallurgical and electrometallurgical methods are de- veloped to produce lead and elemental S from synthetic mixures or concentrates with high purity. Contemporary, this process eliminates S gases and Pb emissions. The elemental S produced is easier to transport and store than is the H_2SO_4 generated by the pyrometallurgical methods.

Investigated experiments and tests included oxidative leaching of PbS in synthetic mixures with H_2SiF_6, electrowinning the leach solution to produce high-purity lead metal, carbon treatmet of spent electrolyte for recycling, and S removal from the leach residue. Investigated experiments by PbS synthetic mixures show satisfactory Pb extraction and appropriate possibility for treatment of natural ore samples and concentrates produced in industrial mineral processing lead-zinc plants in the Republic of Macedonia.

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INCIDENTS IN FLOTATION TAILINGS DAMS AND ENDANGERING OF LIVING ENVIRONMENT

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Abstract

Dangerous and hazardous flotation tailings dams can be source of endangerig of living environmnt in their normal work and also in case of damages incidents in flotation tailings dams can be caused bu natural cathastrophy in the area or malfunctions due to unreliable work.

Chemical haful materials which can get to living environment at damages, can cause endangering of ecological factors (soils, water, air) and through them the whole ecosystem of the area.

In his paper will be shown the incidents on the tailingss dams of the lead-zinc mine Sasa in the Republic of Macedonia.

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Keywords: *incidents, tailings dams, environment*

Introduction

The flotation concentration of mineral raw materials produces large quantities of tailings with significant volumes of water that should be disposed of in appropriate place. The right discharge means better protection of the environment, prevents settling of underflow. It provides certain volumes of water for use in the technological process. The tailing dam that consists of sand dam, settling lake, drainage system and equipment for evacuation of decanted water is an important part of the mine. It must meet the requirements as follows:

- to provide good safety and stability to the dam,
- to have permanent hydraulic input of tailing,
- permanent work of hydrocyclones during separation of sand and overflow,
- to have operational drainage system at any time,
- to provide sufficient time for the physico-chemical processes, or settling of coarse fraction and dissolving of other flotation reagents in order to obtain clear and purified water to be used in the plant or flow into the water courses without contaminating the environment,
- to possess built in collectors to receive and evacuate clear water,
- to have a sand dam with appropriate thickness and porosity to receive and evacuate the clear water,
- to possess sand dam of appropriate thickness and porosity to receive and evacuate clear and percolating water,
- to be economically justifiable in the concentration process.

Over the past years much higher dams (reaching up to 100 meters in height) were constructed. Their economy is seen in the continuation of the lifetime of the drainage system, the collector, the flotation pulp station and the water system between the flotation plant and the tailing pond which are the major costs in construction and maintenance of the tailings dam. Larger dams make possible the housing of flotation waste, to reduce, at the same time; the costs per ton processed ore.

The terrain chosen for the construction of the tailings pond and dam must be examined in order to determine its geological characteristics and rock mechanics.

The construction should be as inexpensive as possible. This requirement leads to the application of the so-called upstream method, since the centreline of the dam extends upstream or downstream. In the application of this method the small starter dam is located at the end of the favourable downstream point, whereas the dam goes upstream. Two major methods are used in dam construction - hydrocycloning and spigoting.

The advantages of the upstream method are its low cost and the time period necessary for the construction during each successive dyke increment.

The disadvantage is that the dam is constructed on earlier deposited unconsolidated slime. The limiting height during the construction of this type of dam (before a failure occurs) led to the less common construction of this type.

The second, so-called downstream method is fairly new system. It has evolved due to the efforts to construct larger and safer tailings dams. Unlike the upstream method, here the centreline increases downstream and the dam is founded on coarse tailings. Most procedures use cycloning or produce sand for the dam construction.The method makes possible the design and construction of the tailings dam with acceptable standards. All tailing dams in seismic areas or almost all-major tailings dams were constructed using the downstream method. The main disadvantage of the method is the large amount of sand necessary for the construction of the dam. There is also a third method the so-called centre-line method - used in the construction of downstream dams, and the crest remains horizontal as the dam wall is built. The advantages are that it requires smaller volumes of sand-fill for the crest at any given height.

Sand dams differ from dyke dams since they are permanently built during the use of tailings pond by depositing new layers of hydrocyclcone sand of lower compactness. The sand comes from the flotation pulp and contains 60 to 75 per cent coarse fractions. The concentration of sulphide minerals in the hydrocyclone sand is higher than in the flotation tailing, particularly higher in the hydrocyclone overflow. With the time, oxidation of sulphide minerals occurs. This changes the permeability of the sand dams and the angle of internal friction among sand grains, which is also important for the static stability of the dam.
The water from the accumulation area penetrates sand dams causing physical, chemical, hydrogeological and consolidation processes to take place during and after the construction of the dam.

Oxidation of sulphide minerals in tailings depends on the time necessary for the reaction of their surfaces with the oxygen in the air. The speed of the oxidation process is related to the quantity of air, temperature, the degree of moisture and the specific surface of oxidising minerals. Of all sulphide minerals - pyrite, which is most common in flotation tailings, is most prone to fast oxidation in a sand dam due to its crystalo-chamical properties and easy comminution. Products of pyrite oxidation are: ferrohydroxide - Fe $(OH)_2$, ferrihydroxide $(Fe(OH)_3$, ferrosulphate $FeSO_4$ and sulphurhydrogen H_2H.

Seeping waters in the tailings pond often contain heavy metals such as iron, zinc, copper, nickel, and manganese. Lead is known to be of limited solubility. Larger presence of individual elements is harmful for the environment. In that regard we must prevent outflow of water with heavy metals in order to keep water safe. Understanding the chemical reactions that take place in the flotation tailings helps to prevent the aggressive action of water of concrete reservoirs whose disasters may cause undesired consequences.

The most serious issue regarding the protection of the environment related to the disposal of flotation tailings in the ponds is the discharge of contaminated waters in surface and underground courses. It must be said that it is more complex in surface courses.

Sasa mine tailings dam

The water from the tailings pond is released into the closest water course - the River Sasa. Most of the waters are released through the overflow collector, and a small part (filtration and percolating waters) is released as drainage waters. Part of the drainage water is filtered in the underground courses. It is assumed, however, that underground courses are less polluted. In spite of all measures for the control and improvement of quality of water that is released (decanting of several days), in some seasons it is contaminated. The lack of dissolved oxygen in water also has a negative impact since it is essential to all species living in waters.

Long-term disposal of contaminated waters in the River Sasa results in the disappearance of a large number of animals and plant species and only the most robust ones survive. The harmful components cause significant physiological and biological changes in animal and plant species creating at the same time harmful materials. The materials, through the global food chain, reach other animal species and eventually human beings.

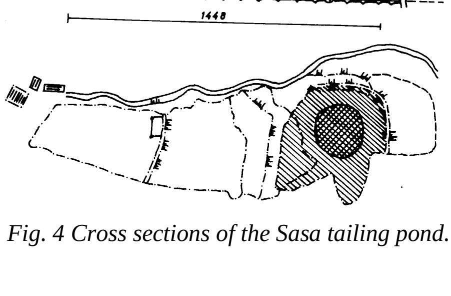

Fig. 4 Cross sections of the Sasa tailing pond.

The long-term release of contaminated waters results in settling of harmful materials in rivers and surrounding land. The most dangerous situations become when flotation tailings directly enter the water-course.

The water flow from the collector is within the limits and ranges on average from 5 to 8 l/s. Drainage waters are also within the limits allowed ranging from 0.25 to 0.50 l/s. In cases when the water is turbid, the overflow collector is sealed until the water is decanted. Protection watershed collectors are built for the intake of surrounding atmospheric waters.

The quality of overflow and draining waters are subject to measurements that include measurement of their physical-mechanical cleanness (solids residue), chemical toxic elements and pH. Measurements are carried out every month and the average maximum results are shown in tables.

The values allowed refer to the legal norms for maximum allowed concentrations (MKD) for the waters of the Sasa River (III category waters). They amount to dry residue from filter 1 500 mg/l; pH value 6.0 - 8.5; Pb = 0.1 mg/l; Zn = 1/0 mg/l; Cu = 0.1 mg/l; Cd = 0.01 mg/l. The previus results (Table 1.) and results obtained from the measurements carried out on waters discharged into the New tailing pond - I phase of the Sasa Mine (Table 2.) indicate that the waters of the River Sasa satisfy the norms required for MKD categorisation.

Table 1 .

sampling site	rN	dry residue (mg/l)			elements (mg/l)			
					Pb	Zn	Cu	Cd
over. col	8,0	700	400	300	0,05	0,14	0,13	0,01
drainage	7,5	1500	1000	500	0,07	0,15	0,03	0,01
tunnel	-	700	400	300	0,01	0,35	0,04	0,02
average	7,5	800	600	200	0,06	0,30	0,03	0,01

sampling site		overflow water, mg/l	tunnel water, mg/l	common, mg/l	allowed concentration. mg/l
Dry Residue	non- filtered	414	1020	1763	-
	filtered	355	380	409	1500
	suspension	69	640	1354	60
pH		8.0	7.5	7.5	6.0-8.5
Ca		102.559	96.144	104.198	-
Mg		1.86692	1.83244	2.1793	-
Na		4.85165	5.49556	5.67332	-
K		6.83857	4.52829	5.05803	-
Al		0.77348	0.25788	0.40304	-
Fe		0.00757	0.01098	0.01245	1.0
Mn		1.84884	1.85961	2.16111	-
P		0.0128	0.0276	0.0166	-
Ti		0.01023	0.0126	0.01257	-
Sr		0.3575	0.43265	0.43037	-
Ba		0.04502	0.04446	0.04554	-
Zn		0.05441	0.4213	0.45764	1.0
Pb		<0.001	<0.001	0.0039	0.1
Ni		0.00133	0.00897	0.0056	0.1
Co		0.00632	0.00573	0.00783	2.0
As		0.00798	0.05048	0.05536	0.05
Cr		<0.001	<0.001	<0.001	0.6
Cu		<0.001	<0.001	<0.001	0.1
Cd		<0.0001	0.00061	<0.0001	0.01
Ag		<0.0001	0.00282	<0.0001	0.02
Tl		<0.01	<0.01	<0.01	-
Bi		<0.01	<0.01	<0.01	-
Ga		<0.001	<0.001	<0.001	-
In		<0.01	<0.01	<0.01	-
B		<0.001	<0.001	<0.001	-
Li		<0.001	<0.001	<0.001	-

Table 2.

Elements mgL^{-1}	Sample					
	1	**2**	**4**	**5**	**6**	**7**
Ca	65.97	59.94	35.86	92.43	43.68	38.17
Mg	14.71	11.26	7.47	18.95	12.38	10.63
Na	5.29	5.29	4.44	6.64	9.32	8.95
K	2.01	2.22	1.42	8.34	3.25	2.96
Al	<0.001	<0.001	<0.001	1.859	0.076	0.194
Fe	0.0106	0.0208	0.0296	2.126	0.162	0.1806
Mn	0.0025	0.0027	0.0059	2.207	0.402	0.415
Sr	0.239	0.229	0.152	0.481	0.220	0.174
Ba	0.048	0.057	0.032	0.106	0.051	0.048
P	0.024	0.005	0.026	0.039	0.016	0.081
Zn	0.014	0.046	0.013	0.297	0.216	0.036
Pb	0.0083	0.0005	0.0063	0.354	0.035	0.0004
Ag	0.0167	0.0227	0.0043	0.0442	0.0086	0.0049
Cu	<0.001	<0.001	<0.001	0.018	0.102	<0.001
Cd	<0.0001	<0.0001	0.00042	0.0051	0.0036	0.0015
As	0.024	<0.005	<0.005	<0.005	<0.005	<0.005
Cr	<0.001	<0.001	0.0020	0.0037	<0.001	<0.001
Co	0.0005	0.0070	0.0016	0.0065	0.0040	0.0026
Ni	<0.001	<0.001	<0.001	0.004259	0.0042	0.0093
pH	6.52	6.41	6.56	6.93	7.43	7.46
Total dry residue, mgL^{-1}	530	539	550	21408	489	447
Dry residue after filt.,mgL^{-1}	274	336	150	493	206	160
Susp. particles mgL^{-1}	256	203	400	20915	283	287

Based on the results obtained it is obvious that water quality is within the limits prescribed with some exceptions. These are mainly the tunnel and joint water which possess enormous quantities of suspended materials. This is due to the exploitation of mineral raw materials since tunnel water comes mainly from caves. The issue should be paid greater attention since the waters from the River Sasa are used for irrigation of crops. It should be mentioned that the tailings pond discharges purified waters and their impact on the environment is insignificant. This indicates that the tailing pond carries out its obligation and purifies the water.

The tailings pond has an impact on air pollution. The wind transports the dry particles from the tailings into the air and the surrounding areas. This action is not dependent on the technology applied or the type of tailings pond. Still, it depends on the weather. This means that air pollution is more intense in summer. Air pollution is easily seen so that the population living close to the pond often complains. Air pollution has a very negative impact on the plant and animal life, first of all on people causing various diseases the main being those of respiratory organs. This is greater when the dust contains heavy metals, silicium or similar metals. The impact of old tailing dams is reduced to the minimum because they have been recultivated. Currently, greatest air pollution comes from the actual tailings pond New pond - phase I where the major polluters are the crest, the slopes and dry beaches of the reservoir.

The climate in the area is entirely mountainous and is characterised by long and snowy winters and short, but fresh summers. The tailings pond is surrounded by high hills in the east and the west. The air currents create large clouds of dust coming from the open areas, slopes and the crest. Depending on the intensity of the wind sometimes the air currents are quite wide, particularly in summer when the top of the pond is dry. Then, south air currents destroy the dam crest. The damage may amount up to one meter in size during the summer period.

Tailings dust is aggressive due to its specific mineralogical composition. It has negative impact on the health of the people. Wind takes the dust and transports particles on the surrounding area and contaminates the land. The effects of the tailings pond on land can be:

- direct, by taking the land away from the place on which the pond is built,
- indirect, pollution of surrounding land, waters and dispersion of tailings dust by air currents.

The selection of the site is an important issue involving a number of conditions (technical, geothechnical, economic, environments and urban planning). The greatest risks come from tailings ponds built in plane areas occupying fertile land.

The tailings pond of the Sasa Mine is situated in the riverbed and the valley of the River Saska. The waste dump extends some 1 450 meters along the river where about 11 500 000 tons of tailngs, 3 180 000 tons of sand and 8.320 000 tons of silt have been discharged.

The earlier tailings ponds have been covered by new soil brought from the surrounding places and planted with grass and locust trees. Forestation has not succeeded, but planting of grass is partially successful.
Recultivation of the pond envisages new and more efficient methods. The land used to be a good valley, but today it is a plane area of greyish colour and a pond with no animal or plant life. Changes of the relief result in changes of the climate that have an enormous impact on the biota. It should be mentioned that the planned dislocation of the road Sasa - Makedonska Kamenica would include part of the good land and reduce the area for construction of the new tailings dam.

The high concentrations of heavy metals in the soil have an impact on its quality and prevent the formation of humus material. They break the bonds between the humus material and the mineral part of the soil that leads to the destruction of the soil and loss of humus and reducing the anti erosive capacity. Heavy metals enter the plants and crops causing a number of biological distortions. Many plants are resistant to saturation of heavy metals and survive. However, saturation of heavy metals in vegetables that are consumed by humans may result in serious health problems. Possible disaster of the dam would result in serious disturbance of the environment and casualties, including great material damage. The issue should be given greater attention.

Experience has shown that disasters are caused due to various factors such as instability of slopes, earthquakes, floods, large quantities of drainage waters, poorly constructed foundations, erosion etc.
In dam construction it is of importance to use all project parameters. Exceeding the dam means disposal of new layers of waste so that the body of the dam increases and the fine particles in the substrate make the large mass unstable.

Retention area should have optimum sides because in case of clogging the overflow collector and reduction of retention area increase the possibility of incidents in the dam. Shortcoming in hydroisolation layer may result in the increase of drainage waters which will have a negative impact on the dam stability. Stability analysis consists of determination of coefficient of safety which is a nondimensional number and expresses the relationship between shear strength of material and mobilised shear strength so that the coefficient of safety for tailings ponds for downstream slope amounts to 1.50.

The environment is a complex system consisting of mutually connected factors. The changes in one factor may cause changes in the other. So, the issue of the protection of the environment from contamination can be solved through integrated and systematic approach. Any partial solutions are not permanent solutions and mean improvisation that take us away from the real solution of the problems. The measures to be taken in protection call for good understanding of the negative effects in mining operation and their elimination. The measures include protection of waters, air, and soil. In environment protection it is important to pay attention to the reduction of pollution of water courses in which waste waters from the tailings pond are discharged. Today, large volumes of contaminated water are recycled and fresh water input does not exceed 5%. As mines use their own wells for the supply of fresh water, the use of the water from the tailings pond would be noneconomical.

Water protection includes certain measures. The most common are those that in the flotation process the toxic reagents are replaced by non toxic or less toxic, settling of water in the pond in order to assist decomposition of residual flotation reagents, clogging of overflow collector when the water is not sufficiently clean, temporal extension of overflow collector and drainage pipe etc.Extension of overflow collector calls for urgent measures since during the dam construction, the flotation waste has not passed the part where the overflow collector ends. The drainage system is functioning well as seen from the measurements carried out by piesometers. However, for better monitoring of filtration and rising waters it is necessary to clean the broken piesometers or replace them with new ones. The impact on ground waters is small. Each raise of the dam results in overflow and run off part of the water into the ground. The problem could be solved through controlled hydroisolation. Contamination of earlier

tailngs ponds has been reduced to a minimum. They have also been recultivated and do not pose any danger to the air.
The new tailings pond is a potential danger to the air. The major sources of pollution are the dam crest, slopes and the dry parts of the beach. As for the dry beaches the most economical solution is control of the water in the accumulation.
For the crest and the slopes several solution are possible one being water spraying with nozzles under high and low pressure.
The low-pressure nozzles work under pressure of 4 bar and have a small range amounting from 15 to 30 meters and economical use of water. This does not require installation of expensive high-pressure pumps.
One of the advantages also is that the low pressure of the jet does not damage the dam. Their disadvantage is that a number of pipes have to be fixed and requires higher investment. Low-pressure nozzles are most common in dam spraying. Combined spraying is when one part (the crest) is sprayed with low-pressure nozzles, whereas the downstream slope is sprayed with high-pressure nozzles - water guns.
Possible solution is spraying with certain suppressants that form crusts husks that connect fine fractions and prevent the formation of large volumes of dust.

Lands formed from discharged flotation waste are called floatisalts. Because of the harmful component parts and the manner of discharge they pose multiple danger to the environment. They have no biological importance and the chances for their revitalisation are very slim.

Part of the flotation tailings of the Sasa mine is used for filling of underground stopes. The advantages of this method are that the tailings pond would occupy smaller area. Unfortunately, only 10 per cent of the tailings are used to fill the underground stopes although it is planned to amount to 30 per cent. Although production costs using the cut and fill method are higher than those in other methods are it should be used more often. The advantages of the method are: it reduces the possibility of lowering the terrain over the underground stoping facilities, it reduces the area necessary for the construction of the tailings pond, and reduces the risk of contamination of the environment.

Conclusions

The possible disaster of the dam may cause great material and ecological damages or losses in human lives. The issue should be paid great attention. Statistics says that collapse of dams occur due to several factors (according to data from USCOLD 1994, US Conference of Large Dams). The most common causes are unsuitability of slopes (amounting to 22%), earthquakes (17%), floods (16%), poorly constructed fundaments, excessive quantities of drainage waters (9%), erosion etc.

Three dam disasters have taken place in the Republic of Macedonia over the past years. They all caused significant damages to the waters, air, and land in particular. Such were the disaters in Zletovo lead and zinc mine in Probiship, the Buchim copper mine and the latest in the Sasa lead and zinc Mine (the last one in September 2003).

The collapse in the Sasa flotation dam formed a crater of 120 - 160 m at a depth of 30 to 40 m. After the disaster over 1.000.000 tons of waste with heavy metals entered the River Kamenica, further on Lake Kalimanci, the River Bragalnica and the surrounding land.

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