Pollutant Effects of the Natural Bacterial Leaching in the Area of Valea Sesei – Rosia Poieni

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Abstract: - The Rosia Poieni low grade copper ore deposit is Romania's largest copper reserve - more than one billion tons of copper ore, averaging about 0.38% Cu and 1.8% S. The floatation tailings are taken to three tailings dams, the most important of them is Valea Sesei; about 27 million tons of waste has been deposited there. An amount of approximately 130 million tons of waste, representing about 76.6 tons of those tons of copper has been deposited so far. A process of acidulation of the water flowing down the dumps started in 1990, the content of metal cations has increased significantly over time (Fe^{2+}, Fe^{3+}, Cu^{2+}, Zn^{2+}, Mn^{2+}, K^{+}, Na^{+}, Mg^{2+}, Al^{3+}) as well as the content of anions, particularly SO_4^{2-}. The pH of this water ranges between 1.5 and 3.5 in most of the creeks it drains into. The name of these creeks is Cuibarul, Sesei and Steregoi.

Key-Words: - bacterial leaching, precipitation, ferric hydroxide, tailings, neutralization, thiobacillus ferrooxidans.

1 Introduction

The low grade copper ore deposit from Rosia Poieni is Romania's largest copper reserve, representing approximately 64.5% of the its total reserve, being estimated to over one billion tons of copper ore with a content of 0.38% Cu and 1.8% S.

The copper mineralization is made up of: chalcopyrite (dominant), bornite, tetrahedrite, enargite (sporadical) associated with: pyrite (dominant), magnetite, hematite, molybdenite and rarely: gold, silver, galena, sphalerite, accompanied by a wide variety of gangue rocks: quartz (dominant), feldspar, biotite, anhydrite, apatite, vivianite, chlorite and calcite.

The mineralization extends beyond the limits of the ore, forming around it an aureole whose content of copper decreases gradually the further from the centre of the ore it is located.

The main technology used in the objective Rosia Poieni includes the open pit mining of the low grade copper ore and its concentration through milling and flotation done in the processing factory within Dealul Piciorului.

2 Analyses and methods

A process of acidulation of the water flowing down the dumps started in 1990, the content of metal cations has increased significantly over time (Fe^{2+}, Fe^{3+}, Cu^{2+}, Zn^{2+}, Mn^{2+}, K^{+}, Na^{+}, Mg^{2+}, Al^{3+}) as well as the content of anions, particularly SO_4^{2-}. The pH of this water is 1.5 ÷3.5 in most of the creeks it drains into. The name of these creeks is Cuibarul, Sesei and Steregoi.

According to the results in table no.1, one may conclude that the creeks Cuibarul and Steregoi undergo a strong process of mineralization, having a big negative influence on Valea Sesei and consequently, even on the river Aries.

By analyzing the correlations between the data presented above and taking into account the input of neutral tributary streams such as Valea Obarsiei, ValeaVintei and Valea Carbunari, one may notice the following phenomena:

a) Most of the salts in the acid water are sulfates
b) A high content of iron ions, 70% of which are trivalent iron ions
c) A total content of suspensions, 70% out of which can form sediments
d) The pH of the water is very acid, and this proves an existing concentration of hydronium ions and sulfuric acid 1÷5%
e) The existence of K^{+}, Mg^{2+}, PO_4^{3-}, Cl^{-} and Fe^{2+} represent the nutrients and the energy source (Fe^{2+}) for the iron and sulfur oxidized bacteria
f) The decrease of the Mn content is due to its precipitation to a pH close to neutral like MnO_2.

All the acid and neutral creeks in the area reach the margin of the tailings dam Valei Sesei.

Table 1. The flow of the acid creeks and the chemical composition of their water

No.	Specification	UM	Valea Cuibar (Halda Cuibarul downstreem)	Valea Steregoi (Halda Geamana N. downstreem)	Valea Muntari (Halda Muntari downstreem)	Valea Sesei (lake dam downstream)
1.	Flow	l/s mc/h	22÷156 79÷562	6÷12 21÷115	6÷12 21÷43	321÷880 1.115÷3.168
2.	Average flow	l/s mc/s	100÷150 360÷540	15÷20 54÷72	10 36	400÷600 1.140÷2.160
3.	pH	----	1.6÷2.5	1.3÷2.5	1.8÷2.5	2.55÷4.50
4.	Total suspensions	g/l	0.64÷1.61	1.4÷2.35	0.37÷1.1	0.27÷1.45
5.	Exact residue	g/l	24.23÷41.59	39.72÷88.07	12.34÷21.41	2.67÷5.48
6.	Cu^{2+}	mg/l	238÷480	525÷1.156	18÷85	17.4÷50.0
7.	Fe^{tot}	g/l	3.775÷4.890	3.35÷8.825	1.08÷2.40	0.038÷0.1
8.	Zn^{2+}	mg/l	85÷172	95÷225.0	28.0÷40.0	10.8÷22.0
9.	Mn^{2+}	mg/l	20÷70.4	87÷103	17.8÷70	12.6÷26
10.	Pb^{2+}	mg/l	0.1÷0.5	0.15÷0.38	0.08÷0.17	0.02÷0.08
11.	Ca^{2+}	mg/l	56÷62	48÷71.6	36÷64.8	56÷130.4
12.	Mg^{2+}	mg/l	24÷43	17÷37	16.5÷24.3	16.2÷28
13.	SO_4^{2-}	g/l	8.9÷14.0	5.9÷14	2.2÷4.8	0.1÷0.35

Table 2. A chemical analyses of the tailings in the dam deposited in Valea Sesei

No.	**Chemical element**	**Formula**	**Content (%)**
1.	Silicon dioxide	SiO_2	64.60
2.	Aluminum oxide	Al_2O_3	14.39
3.	Calcium oxide	CaO	1.35÷2.2
4.	Magnesium oxide	MgO	2.06
5.	Manganese oxide	MnO	0.07
6.	Sodium oxide	Na_2O	3.01
7.	Potassium oxide	K_2O	3.15
8.	Phosphorus pentoxide	P_2O_5	0.38
9.	Titanium dioxide	TiO_2	0.89
10.	Sulfur	S	1.5÷2.1
11.	Iron	Fe	5.1
12.	Copper	Cu	0.2÷0.22
13.	Zinc	Zn	0.015÷0.04
14.	Lead	Pb	0.01÷0.027
15.	Molybdenum	Mo	0.008÷0.01
16.	Arsenic	As	0.008÷0.01
17.	Bismuth	Bi	0.001÷0.0014
18.	Other minor elements (Au, Ag, Re etc.)	Au, Ag, Re etc.	0.001÷0.002

One should bear in mind that presently 27 million tons of tailings containing approximately 3÷4 tons of pyrite are deposited in this dam, the concentration of pyrite is higher in the areas where the mass of the tailings is discharged into the dam. The table no. 2 presents a chemical analysis of the flotation tailings in the dam Valei Sesei.

The mass of the tailings has reached the tailings dam having a ratio of L/S=2/1, with a strong base pH of 10÷12 created by the lime suspension with a 10%

CaO (representing the environment regulator and the pyrite depressor during the flotation process of the mineral). The first mineral to enter the process of oxidizing decomposition is the pyrite, generating the sulfuric acid and the trivalent iron, two highly corrosive components for the activation of the leaching process within the whole mass of the tailings in the dam. The following will be affected:

Valea Sesei and Aries river will be intensively polluted by heavy metal cations and sulfuric acid;

a) The stability of the reverse drill-holes;
b) The stability of the tailings heap will be interrupted;
c) Because of the highly aggressive and acid environment, the whole area will be affected and the phreatic water will be polluted by this water.

One should also bear in mind the effects of the bacteria leaching phenomenon on the waste dump, namely:

a) The emergence of pronounced cracks on the surface of the waste dumps in the upstream area;
b) The increased granulometric decomposition of the dumped tailings;
c) The high occurrence of holes created in the tailings bed caused by emitting gases with a specific odor of sulfur dioxide and trioxide;
d) The emergence of brownish-red slops both on the horizontal surface of the waste dumps, and on the benches of the open pit.

4 Conclusions

By analyzing the onsite situation and by sampling the water and the mineral products, one may conclude that the ore at Rosia Poieni lends itself very well to the process of bacterial leaching, especially in this area of ore exploitation. The natural bacterial leaching started in time because of the following factors:

1. The copper ore from Rosia Poieni has an acid character with an essential weight of pyrite being disseminated in the whole mass of the ore.
2. The whirlpool character of this ore combined with the existence of strongly cracked areas has helped water and air penetrate in, thus the contact ore-water-air was made, and the easy to alter pyrite has oxidized and led to water acidulation, contributing to the formation of the optimal environment for the growth of Thiobacillus type of bacteria.
3. The fact that the ore contains a series of minerals, such as the apatite as a source of phosphor, the feldspar and others as a source of potassium, the limestone and the dolomite as a source of magnesium, ensures the presence of the necessary nutrients for the bacteria, while the existence of the bivalent iron represents the source of energy for the biochemical oxidizing processes.
4. The ore in this environment has its own culture of Thiobacillus type of bacteria that is very well adapted to the conditions in the area. The bacteria create a self-sustained chemical system in the soil, by synthesizing the metabolic products from inorganic compounds. The water, carbon dioxide, pyrite bivalent iron and the nutrients from the ore are the main elements necessary for the optimal development of the bacteria specific to the ore from Rosia Poieni.

The detoxification of the acid water is crucial in order to preserve the conditions required to maintain and mine the tailings from the dam Valea Sesei. The necessary documents were drafted to this end, but the execution of these works is conditioned by finding the required funds.

The biological methods cannot be applied to annihilate this type of phenomenon that has already started on such large areas as they require relatively long adapting periods of new specific cultures of bacteria, the only practical method to be used in this case is the chemical method that will be discussed in another work.

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