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THE CYANIDE LEACH TECHNOLOGY IN GOLD AND SILVER MINING HARMFUL EFFECTS AND SUGGESTIONS FOR REMEDYING

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Rezumat. *Regiunea numită Roşia Montană a devenit celebră din cauza resurselor sale minerale. Produsul cel mai valoros, care asigură traiul pentru oamenii care trăiesc acolo este aurul. Mina de aur a funcţionat timp de mulţi ani, iar poluarea continuă din cauza obţinerii aurului a devenit foarte periculoasă. Toate aceste deşeuri cu conţinut de cianuri sunt periculoase pentru viaţa sălbatică, resursele naturale şi sănătatea omului, dacă nu sunt gestionate în mod corespunzător. Consecinţele toxicităţii cianurii pot fi devastatoare, adeseori ori letale pentru flora şi fauna zonei. Nici până astăzi nu a fost găsită o soluţie adecvată care să împace beneficiile economice ale aurului şi menţinerea dezvoltării durabile.*

Abstract. *The region named Roşia Montană became famous due to its rich mineral resources. The most precious treasure which has been found is the gold. A state-run gold mine functioned for many years and the continuous pollution due to the gold extraction became very dangerous. All these cyanide-containing waste are hazardous to wildlife, natural resources and human health if not properly managed. The consequences of cyanide hazards may be devastating, sometimes killing everything for several miles downstream. It has not yet been found a way of both taking advantages of the economic benefits of gold and maintaining a liveable habitat.*

Keywords: cyanide, Roşia Montana, cyanide hazards, sustainable development of gold mining

1. Introduction

The region named Roşia Montană became famous due to its rich mineral resources. This region is located in Alba County in the Apuseni Mountains of western Transylvania, Romania. The name came from Roşia River which flows in Valea Roşiei [4]. The mineral resources on this area have been exploited since Roman times or before [4]. The most precious treasure that has been found is gold. A state-run gold mine functioned for many years and the continuous pollution due to the gold extraction became very dangerous. For this reason the mine was closed in 2006. Since then a major investor Gabriel Resources from Canada plans to reopen a renovated mine with modern technology of gold extraction [4]. This fact triggered large protests because of the cyanide pollution. On the other hand, it could be useful by providing jobs for the locals and importing funds in country.

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The Romanian Government announced its recognition of the economic benefits of the mining operation, but it also continues to review the environmental impact assessment. The corporation is planning to use a large part of the town and its surroundings in order to gain access to the mine, which is the largest gold deposit in Europe. More than 2000 people must live their heritage; many of them have already resettled in big cities [7]. The investors plan to produce 225 t of gold and 819 t of silver in over 17 years. The project will cost $638m [8], and up to 250 million tonnes of tailings will be stored in a 363 ha pond. The project would inject $4 billion into the Romanian economy, and would provide about 2000 jobs [8]. It seems that the project will be accepted in 2013. For this reasons in this paper are discussed a summarized facts about this topic.

2. Gold cyanidation processes

Gold cyanidation is an industrial technique for extracting gold from ores using cyanide-as sodium or potassium salts to convert the gold to a water soluble coordination complex. It is the most commonly used process for gold extraction [9]. The chemical reaction for the dissolution of gold reported by Hiskey (1984), Gasparrini (1993), Korte and Coulston (1998), follows [2]:

$$2Au + 4NaCN + O_2 + 2H_2O \rightarrow 2NaAu(CN)_2 + 2NaOH + H_2O_2 \quad (1)$$

$$2Au + 4NaCN + H_2O_2 \rightarrow 2NaAu(CN)_2 + 2NaOH \quad (2)$$

The ores are crushed using grinding machinery. Depending on the ore, it is sometimes further concentrated by centrifugal or gravity concentration. The pellets are diluted with strongly alkaline water which pH value is over 10. The alkaline ores can be combined with a solution of sodium-cyanide or potassium cyanide, and sometimes calcium cyanide is also used, which leads to higher costs effective [2]. There are several operations that prevent the creation of toxic hydrogen cyanide. For example, calcium-hydroxide or sodium-hydroxide is added to the extracting solution to ensure that the acidity during cyanidation is maintained over pH 10.5 [2]. Addition of pure oxygen or air accelerates the leaching rate. It must be ensured the high level of dissolved oxygen in the mixtures, because it is consumed during cyanidation. Air or oxygen gas can be purged through the pulp to maximize the dissolved oxygen concentration. Oxygen can also be added by dosing the pulp with hydrogen peroxide solution [2].

3. Effect on the environment

In 90% of gold production the gold cyanidation is used despite the toxic nature of the cyanide. Eisler et al. (1999) and Fields (2001) reported that about 100 million kg cyanide (CN) is consumed annually in North America, of which 80% is used in gold mining. In Canada, more than 90% of the mined gold is extracted from ores with the cyanidation process [2].

The cyanide extraction of gold requires millions of litres of alkaline water and several hundred hectares for heap leaching. The mixtures in tailing ponds contain high concentrations of potentially toxic sodium cyanide (NaCN), free cyanide, and metal-cyanide complexes. During the process may be released other contaminants like nitrogen compounds, lead, cadmium, copper, arsenic and mercury. A large amount of hydrogen-cyanide escapes in atmosphere. Although aqueous solutions of cyanide degrade rapidly in sunlight, the less-toxic products, such as cyanates and thiocyanates, may persist for some years [2]. All these cyanide-containing waste are hazardous to wildlife, natural resources and human health if not properly managed. The consequences of cyanide hazards may be devastating, sometimes killing everything for several miles downstream [2]. The cyanide intoxication in human organism manifests at the intracellular tissue level. The oxygen is not absorbed on passage through tissue. Cyanide inhibits the cytochrome oxidase causing a cytotoxic hypoxia. It is toxic to a number of enzyme systems. The main target enzyme is cytochrome C oxidase, the terminal oxidase of the respiratory chain and involves interaction with the ferric ion of cytochrome a_3. [1].

4. Cyanide Hazards

"Fish killed from accidental discharges of cyanide gold mining wastes are common. In Colorado, overflows of 760,000 L NaCN-contaminated water from storage ponds into natural waterways killed all aquatic life along 28 km of the Alamosa River (Alberswerth et al. 1989). In August 1995, in Guyana, South America, a dam failed with the release of more than 3.3×10^9 L cyanide-containing gold mine wastes into the Essequibo River, the nation's primary waterway, killing fishes for about 80 km, and contaminating drinking and irrigation water (Da Rosa and Lyon 1997)" [2]. The cyanide containing wastewater is also dangerous for birds. Da Rosa and Lyon (1997) reported that between 1983 and 1992, at least 1018 birds representing 47 species were killed when they drank cyanide-poisoned water from heap leach solution ponds at a gold mine in South Dakota. The consequences of the accident at Baia Mare in 2000 and uncontrolled mining, are the toxic components increment in environment like, 110 times the legal limit of zinc; 70 times the legal limit of cadmium; and 3.4 times the legal limit of arsenic [5]. In the Someş River below Baia Mare, the plankton returned to 60% of normal within 16 days of the spill [10]. There is also considerable chronic pollution of local rivers, such as the Roşia and Abrudel streams that flow into the main Arieş River. Soils within historic mining areas cannot be used for agricultural purpose. [2, 4]. About 62% of families interviewed in Roşia Montană had one or more members who sought medical attention for serious illnesses in the past year. Possible causes of health problems could include occupational hazards (particularly mining), fatty diet, stress and alcoholism. The occupational hazards can be the absence of proper security clothing, lack of information regarding the toxic components, poor conditions and so on [4].

5. Effect on the local economy

Currently the main source of income in Roşia Montană is mining, accounting for over 90% of the income. Mining activities contribute significantly to government's funds via taxes, and to the local communities funds via supplies and services [4]. Poverty currently affects over 50% of the people in the region. The number of schoolchildren declines, homes are being sold, health risks and impacts are high, and some 50% of the population already receives pensions or social aid. The transport logistics and infrastructure are extremely undeveloped. The polluted and less impressive location is not attractive to investors. Therefore, it has to be invested major funds for the development of Roşia Montană in order to make it attractive for the investors.

6. Cyanide remediation processes

Cyanide is a singly-charged anion containing unimolar amounts of carbon and nitrogen atoms triply-bonded together: C≡N- or CN-. It is a strong ligand, capable of complexing at low concentrations with metals. Free cyanide refers to the most toxic forms of cyanide: cyanide anion and hydrogen cyanide. [3]. All cyanide species are considered to be acute hazardous materials. The mean lethal dose to the human adult is between 50 mg/L and 200 mg/L [2]. Wasted streams originating in the gold extraction get into soil and plants absorb them. This process is followed by pollution of the whole environment. Various attempts were made to reduce the serious damage. It may be used physical processes like adsorption, oxidation and complexation. These processes can be accomplished with dilution, using membranes, electrowinning, hydrolysis and distillation. These applications are less efficient, but in most cases the products are reactivated and recycled for further use [3]. Several chemical procedures are also used for reduce or eliminate the toxic residues. The most popular method is the application of oxidants, like oxygen, ozone, hydrogen peroxide, hypochlorite. The products of this reaction are less hazardous, but the cyanide cannot be recycled. For example, the Degussa process shows that hydrogen peroxide reacts with cyanide to produce cyanate and, when added in excess, nitrite, carbonate or nitrate forms [3]. These reduce the concentrations of cyanide compounds, but do not completely eliminate them. Most of the remediation processes need further treatments. Some processes reduce the toxicity level below the imposed value limits, but they are costly. Such processes are photolytic ozonation, electrodialysis, and reverse osmosis [3].

7. Conclusions and recommendations for sustainable development for Roşia Montană mining

Sustainable development, in which the needs of future generations are not compromised by the activities of today [4]. Roşia Montană has considerable social, environmental and economic problems. Being a disadvantaged zone, it requires substantial coordinated effort by all stakeholders to address these problems for social, environmental, economic and investment aspects.

Since 2008, The European Union has allowed no more than 10 parts per million (PPM) of cyanide at mining operations. According to the investors announcement the Roşia Montana cyanide levels will be between 5-7 PPM. They plan the recycling of the cyanide substances almost completely. The rest of the residuals will be detoxified. The detoxification technology is not specified in their project. After the detoxification process, the remaining water will be discharged into a tailings dam, which will be 188 meters high and nearly 600 meter [11]. It has to be taken into account that the collected contaminated mixture is a danger for the fauna, especially for the birds.

In U.S. such tailing dam was built also to protect wildlife, and for that various techniques were used including cyanide recovery, cyanide destruction, physical barriers, hazing, and establishment of decoy ponds. Strurgess et. al (1989) reported that the owners had to pay penalties for each dead bird. Under existing legislation 92% survival was considered.

Cyanide concentrations in the water (160–207 mg/L) were reduced at one Nevada site using naturally detoxified recycled tailings water. Lowering the cyanide concentrations in tailings ponds with hydrogen peroxide has been successful at a few mines in Nevada [3].

In South Dakeota the mine owners developed a technology to reduce cyanide and heavy metals by 95%–98%. In the process, cyanide was degraded to carbon and nitrogen; ammonia to nitrate; and heavy metals removed by adsorption or absorption [3].

In a decreasing order of economic efficiency, the common processes for recovering the solubilized gold from solution are: carbon addition to the pulp and/or electrowinning.

From the human health perspective, the reduction of diseases requires information, awareness and a concerted effort to reduce the incidences of smoking as well as the risk posed by the other categories, to ensure that modern medical services are available. There are expected to be significant numbers of mostly male job seekers entering the area. It is important the health awareness, which will be developed with topics: individual hygiene, reproductive health, amongst other issues. [4].

The Gabriel Company plans to build a best practice modern mine and realization of highest environmental standards. The environmental sustainability topic shows four main areas of objectives: landscaping and forestry, water, tailings dam safety and noise and vibrations. Planting of 1000 hectares of forestry to replace 255 hectares to be deforested, the wasted areas will be rehabilitated and re-vegetated. It will monitor the level of noise continuously and will respect the relevant

standards. The wasted water will be collected and cleaned, and 85% of the industrial water will be recycled [5].

The project triggers some professional's doubts. Acad. Ionel Haiduc's account holds that the open pit exploitation produces a significant degradation of the natural environment, destroys the landscape, leaving behind four huge craters and massive deposits of sterile material, as can be seen in the open pit mine in the vicinity, at Roşia Poieni. The pollution of air, water and soil in the area, produced by the open tailings and the massive transportation with heavy equipment of huge amounts of ore and sterile material cannot be ignored [6].

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