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IMPACT OF AN ABANDONED MINING SITE - CENTRAL FLOTATION PLATFORM

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Abstract: *The paper highlights a strong environmental impact due to a mining perimeter (Central Flotation - Baia Mare) in which significant quantities of complex and concentrated ores were abandoned without the most basic protection measures against environmental factors. The period of time since the cessation of activity has been more than 14 years, during which time an extreme reactivity took place, generating an acid drainage with very low pH and heavy metals exceeding hundreds and even thousands of times the maximum allowed values. These waters reach the natural receptors directly or infiltrate the groundwater. Another serious aspect is given by the fact that this site is located in the middle of the busiest community in Maramureș County (upstream of Baia Mare) and close to rural communities that practice agriculture and animal husbandry. Alongside the already existing environmental problems in the perimeter there is also added seepage of mine water through the exit of the tunnel from the Herja mine. Also adjacent is the Central pond with a supply of mine water and toxic dust.*

1. Introduction

In 2006, the mining activity in northern Romania was stopped, generating negative economic, social and especially negative environmental consequences, through the way in which the concept of "closing the mining perimeters" was understood. Currently (2020), a long time after the closure of the mining activity, the environmental impact is becoming increasingly more aggravated and with the pollutants being transferred over exceedingly long distances. Acid drainage formed in the mining perimeters generates transfer phenomena affecting the ecosystem over large areas, especially in the mountainous areas of northern Romania with rainfall and an important hydrographic network.

A case with a special feature is the mining perimeter and its proximity defined by the Central Flotation platform. The Central Flotation was a complex ore processing plant in Baia Mare. This platform with the buildings and landfills of mining was left in a state of abandonment, having two types of environmental consequences. The buildings and annexes are in an advanced degradation stage, they are covered with asbestos cement which is due to crushing releases of asbestos fibers into the environment. Dust with a content of over 50% crystalline silica is entrained from mining waste. The two powders, asbestos and crystalline silica are sclerosing, extremely toxic and with a strong impact on the health of the population. The waters formed as a result of the reaction between the sulfides contained in the mining waste and the precipitation water loaded in oxygen, determine a very high reactivity, being accentuated by the fineness of the mining waste and the degree of spreading on a very large surface.

These waters have a strong acid character and are loaded with heavy metals. They flow directly into the Sasar River and seep into the groundwater. The platform was partially paved with concrete, but there are sections with concrete discontinuities through which pollutant leaks take place. The geological structure consists of the terrace of the Sasar River, a permeable structure. The latter creates the conditions for the infiltration of toxic waters into the aquifers.

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2. Description of the impact and current status of the platform

The platform is a source of air, water and soil pollution, located in the vicinity of the busiest urban and rural areas in Maramureș County. The main source of pollution is landfills left to chance, without protection by waterproofing or relocation as provided in the rules of good practice, including Romanian legislation [1], [2].

Inexplicably, these landfills have remained exposed to environmental factors after so many years, although their reactivity is known. Even without performing laboratory analyzes, a simple field visit shows signs of advanced toxicity felt olfactory by the released odor, visually by the selenarian landscape and by the way the concrete structure is degraded, both on the plateau area and the walls of the resistance structure of buildings or panels for separating landfills. The aggressiveness of acidic waters is noticed by the decomposition, almost entirely, of the concrete components - the binder (cement), and the steel from the concrete composition. The solution was and remains to intervene as soon as possible to clean up and confine this waste. Abandonment in this state of a site near urban and rural agglomerations is a major irresponsibility.

Compounding this situation is the added supply of mine water from the Herja mining perimeter through the Herja tunnel - Central Flotation. Since the last period of activity of the Herja mine, this tunnel was completed and used to transport the ore on the belt from the mine's underground directly to the Central Flotation. Another uninspired decision was to design the closure of the tunnel at the flotation exit by building two dams and backfilling the space between them, in order to accumulate water in the underground of the mine and the subsequent discharge through the base gallery inside the Herja mine, where there is a wastewater treatment plant. The difference in level between the exit of the tunnel and the base gallery is 220 m. Under these conditions, two major risks could have been anticipated, described and published in a scientific paper immediately after the execution of the closure works [3]. These inevitable risks were given by the chemistry of the mine waters and their interaction with the concrete used at closure and the difference in level by the accumulation of mine water in the underground of a cracked, fragmented, faulty structure, both naturally through geological structure and mining. drilling - shooting, excavation, on large horizontal and vertical surfaces, through which inevitably the mine waters generated leaks and were unlikely to reach the level of the base gallery. Shortly after the closure of the works (5 years), the mine water percolated the wall inside the Central Flotation with significant mine water leaks. Personal monitoring of the perimeter allowed the identification of these evacuations in 2017. The mine waters reach the premises of the Central Flotation, adding to those existing in the perimeter of the flotation.

Within the Central Flotation, the complex ores from the Baia Mare region were processed with polymetallic sulfide contents and with large quantities of pyrite and marcasite, which represent the triggering mineralization of the acid drainage. The quantities of ore and concentrate in climatic conditions specific to the area (temperate climate with precipitation, followed by hot periods, dry with winds) allow the ideal conditions for oxidation of sulfides with sulfate formation, which become soluble and easy to transport through the environment. Through careful monitoring, especially in the last 10 years, this cycle of sulphate formation and their entrainment during periods of precipitation was systematically noticed. Oxygen-laden precipitation water (free oxygen) contributes to the formation of new sulfates, which in turn will be entrained in the next precipitation. These phenomena are visible and captured in the following photos.

Figure 1 Presence of sulphates formed on the concentrates remaining in the mining perimeter (in dry periods that disappear during precipitation)

Figure 2 Mine waters in the perimeter of the Central Flotation

Figure 3 Framing the site in the natural landscape of Baia Mare and the presence of acidic waters and the impact on concrete

3. Analysis on water samples taken from 4 locations

In July 2020, water samples were taken from 4 locations of the perimeter of the Central Flotation platform, where water stagnates or is released into natural receptors or infiltrates into the groundwater. The sampling points were selected according to the visual impact both in terms of volume and color, close to the quantities of mining waste remaining on the platform. It is to be mentioned that the months of June and July of 2020 were very rainy, which led to the intensification of oxidation reactions of sulfides, the formation of soluble secondary minerals (sulfates, hydroxides, etc.) and strong acid drainage. The tests were performed in the laboratory of SC Vital SA Baia Mare. This company is interested in the impact of acidic waters in the Baia Mare area because some of it inevitably reaching the sewage network and negatively influencing the treatment of domestic water. The results were reported to the legislation in power, respectively GD no. 188/2002 with the 2005 update on the conditions for discharging wastewater into the aquatic environment. The principles of this judgment are based on a series of rules of good practice with restrictive requirements, but there are major inconsistencies between reality and what they mention. An eloquent example in this sense is "Romania declares its entire territory as a sensitive area" due to its geographical location within the Danube and Black Sea basins. Also, the law stipulates the obligation to ensure the waterproofing of all landfills, any leaks, rainwater flowing from these landfills must be collected and treated. The provisions also apply to the discharge of wastewater into permeable soils or depressions with naturally occurring runoff. For heavy metals, the sum of ions must not exceed 2 mg / dm^3.

The determinations performed and compared with the limit values show significant exceedances with a strong environmental impact. The following table shows the determined values, the limit values and how many times they are exceeded, as well as the alarming pH values.

Table 1 Laboratory values of the main indicators on acid drainage and their exceedances compared to the maximum permitted limits

No	Parameters determined	M.U.	Admitted limit	Test 1		Test 2		Test 3		Test 4	
				The value determined	n	The value determined	n	The value determined	n	The value determined	n
1	pH	-	6,5-8,5	1,81	**-**	2,38	**-**	2,22	**-**	2,17	**-**
2	Iron	mg/dm^3	5,0	5660	**1132**	4390	**878**	3510	**720**	1350	**270**
3	Copper	mg/dm^3	0,1	62,6	**626**	2,5	**25**	47,2	**472**	20,5	**205**
4	Arsenic	mg/dm^3	0,1	> 3,0	**> 30**	1,7	**17**	> 3,0	**> 30**	> 3,0	**> 30**
5	Lead	mg/dm^3	0,2	138	**690**	119	**595**	110	**550**	126	**630**
6	Cadmium	mg/dm^3	0,2	< 0,02	**-**	< 0,02	**-**	< 0,02	**-**	< 0,02	**-**
7	Zinc	mg/dm^3	0,5	347	**694**	680	**1360**	226	**452**	729	**1458**
8	Residue filtered at 105˚C	mg/dm^3	2000	32564	**16,28**	20605	**10,3**	7722	**3,86**	11588	**5,79**

$$n = \frac{\text{determined value}}{\text{maximum allowed value}}$$ (how many times the allowed value has been exceeded)

From the performed analysis, there are significant exceedances of heavy metals and the strong acid character of the waters located on the Central Flotation field.

4. Conclusions

Such a situation is unacceptable for a European country that declares itself a "sensitive area", given the Danube and the Black Sea, but in reality, there are many mining sites with a high negative environmental impact. These mining sites required closure or conservation through rehabilitation and ecologically friendly works. Most sites have been virtually abandoned without any measures to reduce the environmental impact. One such site located in the middle of densely populated area is the perimeter of the Central Flotation, where there are quantities of ores and mining concentrates (sulfides) that have a very high reactivity to environmental factors, generating a strong acid drainage. This impact is confirmed by laboratory measurements, which show the acidity and exceedingly high concentrations of heavy metals. These acidic waters are discharged directly into the natural receptors or infiltrate the groundwater. The reactivity of sulfides is given by their oxidation, especially by the presence of pyrite and marcasite in significant quantities, which lead to the formation of sulphates visible in short periods of time after precipitation, which in turn are soluble, washed and entrained in the environment. This cycle is very visible at repeated visits during periods of heavy rainfall and shortly afterwards. In 2020, a year with significant amounts of rainfall alternating with hot and dry periods, the phenomenon has become very visible. Researchers systematically monitor this site through field visits, signaling a strong visual and olfactory impact by releasing sulfur dioxide following oxidation reactions and dust entrainment during windy periods.

A perimeter like the one presented must be rehabilitated and be made ecologically friendly as soon as possible, in order to stop the negative effects on the local area and on the health of the population

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