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(SUMMARY OF PhD THESIS)

CONTRIBUTIONS REGARDING POLLUTION AND DEPOLLUTION IN THE PERIMETER OF CERTEJE, HUNEDOARA COUNTY

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INTRODUCTION

Pollution is one of the most important factors, which, by seriously disrupting the ecological balance, leads to the disappearance of some plant and animal species. Pollution has a harmful effect on nature and sometimes takes its revenge (NĐIŞAN and CHERECHEȘ 2000; NĐIŞAN et al., 2001). Mining is an activity of mankind that contributes to the progress of civilization, to the economic growth of a state. However, mining has a significant impact on water, the landscape and the environment.

The main goal of European policies is to provide an environment in which "the level of pollution does not give rise to harmful effects on human health and the environment", and vulnerable groups of the population are protected. They are embodied in the 7th Environment Action Programme, the EU Health and Environment Strategy and the Pan-European Committee for Environment and Health of the World Health Organization. Technological development, mechanization, agro-chemicals and, more recently, genetic discoveries have enabled constant increases in yields and led to structural changes in agriculture. Consequently, human influence began to leave an increasingly important imprint on the landscape, especially the radical changes in agricultural management after the Second World War. Such processes were accelerated by the entry into force of the Common Agricultural Policy, in 1957, whose initial objective was to ensure food production for the countries of the European Community, in the post-war period. Supporting agricultural production through the provision of subsidies was the main factor in the improvement of technologies.

After processing the ore, the waste material was transported to the waste dump. The largest is the Mealu tailings residue which contains 4.6 million ores of finely shredded waste that is incorporated into the acidic water that produces the mineral pyrite (mineral from the sulphide class). It was actively used from 1984 to 2006.

After two and a half centuries of gold mining, the settlements in the Metaliferous Mountains that brought tens of tons of gold and silver appear in a desolate state, despite the wealth in the depths of the Hunedoara mountains. In the village of Certeju de Sus in Hunedoara, the mining tradition stretched over more than two and a half centuries, until the middle of the 2000s.

Chapter 1

ANALYSIS OF ENVIRONMENTAL ASPECTS REGARDING HEAVY METALS POLLUTION

The first chapter refers to soil pollution, it being known that soil fulfills several functions: ecological, technical/industrial, socio-economic and cultural. The causes of soil degradation are either natural or directly or indirectly related to human activity. Soil pollution is considered a consequence of unhygienic habits or improper practices, due to the random removal and storage of residues resulting from human activity, industrial waste, or the improper use of chemicals in agriculture. As with air and water, soil pollution can be physical, chemical, biological and radioactive in nature.

The history of the location of the gold-silver deposit in Certej is then described.

Chapter 2

DESCRIPTION OF THE NATURAL FRAMEWORK OF THE RESEARCHED AREA

The second chapter describes the general framework of the research, the physical-geographical conditions of the city with the local particularities of the studied area and the study of historical pollution. The former Certej exploitation is located on the territory of the Certeju de Sus commune, Hunedoara county, about 20 km from the city of Deva. Access to Deva from Bucharest can be done on European roads E86 Bucharest - Braşov - Sibiu - Deva (400 km) or E86, E81, E70 Bucharest - Pitesti - Sibiu - Deva (365 km). From the city of Deva, access to Certej is ensured by the European road E79 Deva - Brad and by the county road that crosses the localities of Şoimuş - Certeju de Sus - Hondol - Săcărâmb or the localities of Certeju de Sus - Măgura Topliţa - Topliţa Mureşului. In addition to the mentioned county roads, on the territory of Certeju de Sus there are also various access roads to the current or closed mining perimeters.

The Certej area is located in a region where gold mining activities date back several hundred years. The underground works, controlled by the Romanian state, started in the early 1970s and initially consisted of coastal, directional and transversal tunnels and then continued through open-pit mining.

The metals that are found in the highest concentration in the soil are: magnesium, sodium, calcium, iron, aluminum, but there are also soils that are deficient in heavy metals (such as Co, Cu, Fe, Mn, Mo, Ni or Zn), which are essential for healthy plant development. Regarding the degree of soil pollution with heavy metals, they differ depending on many factors such as: the level of contaminant concentrations, the geographical area, the type of soil, the type of pollution source, the activities of removing contaminated waste from a certain area etc.

Chapter 3

STATUS OF KNOWLEDGE OF POLLUTION DUE TO CERTEJ EXPLOITATION BEFORE CLOSURE

Chapter 3 presents the behavior of pollutants on the environment starting from the exploitation period and a synthesis of the determinations regarding pollutants and historical pollution sources. Metals are natural components that are part of global ecosystems. Some of them are essential for the good development of plants and organisms, others, on the other hand, can be toxic for them, even at very low concentrations. Soil pollution with heavy metals can be present in the environment in a wide range of oxidation states and coordination numbers, which are also correlated with their toxicity.

The Coranda deposit, a fot an exploitable deposit, the types of ore in the quarry area, a series of elements are found: Au. Ag, Pb, Zn, As, Cd, Cr, Fe, Mn and HG. The Coranda quarry occupies an area of approximately 85 ha.

Table 3.1. The results of the soil samples from the Coranda Quarry

No	**Name of the test**	**pH**	**mg/kg dry substance**								
			Cd	**Co**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Zn**
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1’	La gura sectorului Băiaga 10 m	6,41	6,5	SLD	140	62	4247	5121	10	170	810
2'	Haldăde steril Băiaga	6,71	12	9	12	78	4391	1573	20	350	2320
3'	La baza haldei Băiaga	8,06	6	SLD	17	36	3169	1683	31	50	190

4'	La 15 m de halda de steril Băiaga - în dreapta	7, 47	SLD	SLD	10	10	1967	841	SLD	100	140
5'	Cariera Coranda	3, 72	6	7	19	135	4724	760	62	1600	670
6'	Cariera Coranda-halda mică de steril	4, 06	SLD	SLD	25	47	3692	311	8	880	240
7'	Cariera Coranda-halda mare de steril	5, 44	10	12	22	104	4647	1554	25	880	1270
8'	Cariera Coranda-halda de steril 40... 50 m	6, 31	8	12	25	99	2613	2743	50	220	590
9'	Sector Beruard în fața galeriei de mina	7, 71	SLD	9	25	73	3193	3658	12	220	460
10'	Sector Bernard-din halda de steril	7, 64	7	7	12	52	2668	4573	37	320	650

The underground mining works, carried out over time, led to the formation of underground voids formed by galleries, shafts, shafts, backfilling chambers. During the underground works, the hydrostatic level had to be lowered, and the water was extracted by pumping. Through these processes, the initial hydro-chemical regime was disturbed by the considerable increase of the aerated and permeable zone, favoring the chemical reactions of oxidation and dissolution as well as the preferential directing of rainwater infiltration towards the more mineralized areas. Consequently, mine waters are acidic, highly sulfated, have high contents of Fe, Zn, Mn, Al, Cu, Sr, As, Co, Ni, Cr. The iron present in very large quantities precipitates in colloidal Fe(OH)3- or cryptocrystalline (FeOOH) form.

Surface mining creates conditions for the emergence of potential dust emissions in periods without precipitation. The main sources of dust emission are represented by: heavy vehicles traveling on unpaved roads, wind erosion from excavated surfaces or from dry, unvegetated or unconsolidated land surfaces, drilling and blasting (rifling) activities, as well as loading, unloading and storage activities of ore, waste rock.

Chapter 4

STATUS OF ENVIRONMENTAL FACTORS DURING THE CLOSING PERIOD OF THE MEALU VALLEY AND MIREțULUI PONDS

4.1. LOCATION DESCRIPTION OF THE VALEA MEALU

Chapter 4 presents the results regarding the state of the environmental factors for the two ponds of the Certej branch, by making them safe and greening them.

Valea Mealu, on which the settling pond with the same name is located, is a left tributary of the Certej river, approx. 3 km from the premises of the Certej Preparation Plant, outside the buildable perimeter of the Certeju de Sus commune. The sampling of the 8 soil samples were collected at the edge of the pond, around it, with the exception of profile S98, collected from about 50 m, in the southwest direction. The values obtained on the two testing levels for the chemical reaction of the soils and for the chemical element Fe were compared with the values obtained in the blank reference profile and are presented in the table below.

Table 4.1. Physico-chemical characterization of the soil samples collected from the location of the Valea Mealu Pond

Indicator	UM	S97/1	S97/2	S98/1	S98/2	S99/1	S99/2	S100/1	S100/2	S101/1	S101/2	S102/1	S102/2	S103/1	S103/2	S104/1	S104/2
pH	-	5,54	5,20	5,18	5,03	5,22	4,81	4,88	4,66	4,38	4,36	5,51	5,96	6,50	5,22	3,68	4,17
umiditate	%	1,69	3,01	1,46	1,57	1,8	0,55	3,42	0,34	0,5	0,43	0,34	0,32	0,84	0,63	1,08	0,29
Cd	mg/kg su	11,78	<0.01*	<0.01*	<0.01*	<0.01*	<0.01*	<0.01*	<0.01*	<0.01*	<0.01*	2,78	<0.01*	2,65	2,27	<0.01*	<0.01*
Cr tot	mg/kg su	<0.1*	22,63	18,23	15,41	28,51	35,04	24	34,32	19,72	26,11	70,65	60,11	45,65	44,26	28,48	26,79
Co	mg/kg su	<0,2*	<0,2*	<0,2*	<0,2*	<0,2*	<0,2*	<0,2*	<0,2*	<0,2*	<0,2*	17,48	<0,2*	<0,2*	<0,2*	<0,2*	<0,2*
Cu	mg/kg su	219,8	28,64	32,29	21,4	<0,05*	<0,05*	19,84	20,18	<0,05*	<0,05*	32,76	22,3	<0,05*	25,63	<0,05*	<0,05*
Fe	%su	2,89	2,41	1,68	1,23	1,6	1,05	1,38	1,59	1,17	1,61	2,35	2,02	1,99	2,57	1,21	1,26
Mn	mg/kg su	2892	655,53	1160,43	889	517,83	538,81	812,95	727,02	111,16	108,49	720,38	638,24	802,56	1039,49	673,34	451,24

Ni	mg/kg su	50,63	41,02	23,72	18,14	31,56	30,83	29,27	32,78	<0.08*	25,86	99,95	72,74	44,06	45,96	29,93	28,14
Pb	mg/kg su	1272,46	99,03	316,45	75,46	32,29	<0.2*	28,07	25,83	<0.2*	19,85	22,57	<0.2*	27,78	89,81	75,16	36,7
Zn	mg/kg su	1700,48	175,66	349,66	215	70,57	38,38	52,17	43,26	30,88	41,20	82,64	57,52	87,26	170,88	225,28	47,76
As	mg/kg su	48,59	7,17	21,3	17,4	7,44	6,13	7,3	5,78	4,46	4,18	8,48	4,15	8,48	13,37	4,77	1,5
Sulfati	mg/kg su	332,8	252,7	217,9	173,8	119	99	93,8	94,1	38,6	75,1	520	557,9	483,9	647,4	1052,8	914,4
Sulfuri	mg/kg su	<20*	<20*	<20*	<20*	<20*	<20*	<20*	<20*	<20*	<20*	<20*	<20*	<20*	<20*	<20*	<20*
Hg	mg/kg su	-	-	0,169	0,146	-	-	-	-	-	-	-	-	-	-	-	-

* - the limit of the analysis method, S - soils with sensitive use

S - soils with less sensitive use

In conclusion, in the site area of the Valea Mealu settling pond, no significant pollution of the soil environmental component was evident. The exception is sampling point S97, located in the southern part of the pond, where a significant pollution of the soil environmental component is evident at the first depth, as a result of exceeding the intervention threshold for soils with "sensitive" uses, for metals quality indicators heavy - Cd, Cu, Mn, Pb, Zn and As.

Comparison of the results obtained with the limits imposed according to Order no. 1146/2002 highlighted the inclusion of the Valea Mealu stream, upstream of the Valea Mealului settling pond (P64), in:

- first class for quality indicators Ca, Cu, Zn, Cd, Ni, Hg

-class II for quality indicators filterable residue, sulfates, chlorides and CCOCr

-class III a for the Mg quality indicator

-5th class for the total Fe quality indicator

Taking into account the fact that the Mealu river joins the decanted water from the pond and then flows together into the Certej stream, sample P62 was also considered the surface water sample, downstream of the Valea Mealu settling pond.

4.2. DESCRIPTION LOCATION OF VALEA MIREȘULUI POND

The sterile settling pond of the Preparation Plant no. 1 Certej was designed and executed as a result of the serious damage caused to the existing settling pond, at the end of October 1971, as a result of which the pond could no longer be used, and the operation of the preparation facilities stopped. The pond was built in the period 1972-1975, in the form of an emergency pond, to ensure the decantation of the sterile turbidity resulting from the Preparation Plant no. 1.

The sampling points were located in the area of the pond, around it, with the exception of the S107 profile, collected from about 100 m, in the northwest direction, on lands not owned by Minvest (with sensitive uses).

The values obtained on the two testing levels for the chemical reaction of the soils and for the chemical element Fe were compared with the values obtained in the reference profile (control), and the values obtained for the rest of the quality indicators were compared on both harvesting levels with the values set by Ord. MAPPM no. 756/1997, for soils with "sensitive" uses.

The comparison of the values obtained in all sampling points with the values obtained in the control samples showed the following:

- the pH of the soil generally presents values within the same range of variation as that of the control sample, which indicates a slightly acidic reaction; the exceptions are profiles S105 on the first depth and S108 on both depths where the values obtained are somewhat higher than those of the control sample;

- for the quality indicator Fe, much lower values were found compared to those of the control samples at both depths, for all collection points.

Interpretation of the results obtained in accordance with the provisions of Order no. 756/97, for the "sensitive" land use category showed the presence of the analyzed quality indicators, in most situations, below the alert threshold and even within the limit of normal values, at all testing levels. The exception is profile S110 (collected from the northeastern part of the pond) where, for the quality indicators Pb (on the 0-10 cm level) and As (on the 30-40 cm level), the intervention threshold is exceeded.

Table 4.7. Analysis of soil concentrations

Cod proba	Localizare	Cl	SO_4 ppm	Zn ppm	Cd ppm	Pb ppm	Cu ppm	Cr ppm	Ni ppm
T 1	Taluz iaz	5,68	1300,0	6,997	< 0,03	< 0,08	0,392	<0,05	0,102
T 2	Plaja iaz	5,68	1640,0	0,261	< 0,03	< 0,08	0,030	<0,05	<0,02
CMA - conf. Ord. 95/2005		15000	20000	50	1	10	50	10	10

It is concluded that: in the location area of the Valea Miresului settling pond, no significant pollution of the soil environment component was evident in the analyzed quality indicators. The exception is the S110 collection point, where a significant pollution of the soil environmental component is evident, as a result of exceeding the intervention threshold for soils with sensitive uses, for the Pb and As quality indicators. The main source of water pollution is the tailings source from the body of the pond, rainwater coming into contact with the waste from the warehouses.

Chapter 5

CURRENT STATE OF ENVIRONMENTAL QUALITY IN THE CERTEJ AREA

5.1. THE EFFECT OF THE ECOLOGIZATION WORKS OF THE PONDS

The greening of Certej's waste has the purpose of reducing the effects of pollution on the surrounding ecosystems and soils.

The development of the pond's surface by creating a slope of 5%0 on the longitudinal axis of the pond's beach from the upstream ensured the drainage of the waters from the precipitation to the guard channels. The guard ditch is unclogged to ensure its functionality. At the foot of the dam, the downstream area was drained and consolidated.

The restoration works in the forestry circuit by reforesting the beach with tree species from the area, acacia, birch, sea buckthorn, led to the improvement of the consolidation of the pond.

Alterability defines the ability of rocks to resist alteration factors. It depends primarily on the combined effect of the degree of resistance of the component minerals, together with the deposit conditions, texture, and structure. Very shale rocks (crystalline shale, clay shale, marl, etc.) change more easily than massive ones, the cause being exfoliation. The effusive rocks and aplites are more resistant than the intrusive rocks, gneisses and coarse mica. The coarse horizon is generally made up of sands, sometimes clayey, with levels of gravel Clay rocks, like those in the Valea Mireșului pond, whose minerals represent the last stage of alteration, are resistant to hypergenesis conditions, from the surface of the crust within which they were formed by chemical alteration processes. Compared to physical agents, alterability is also conditioned by the degree of lithification. Thus, a compact argillite is more resistant than the plastic clay from which it was formed, while clay shales are more easily altered, although they have a higher degree of lithification, since schistosity favors disaggregation.

In rock masses, discontinuities filter water in relation to frequency, aperture and hydrodynamic gradient. In the filtration process, mineral dissolutions or transformations occur, which are initially limited to discontinuity surfaces, and then expand in their vicinity, depending on the density of the network of microcracks and the nature of the minerals.

The initial cracks facilitate drainage, diffuse it laterally or towards the main fractures, making it possible to impregnate the rock with water-bearing substances, either osmotically or absorbently, as a result of the low infiltration speeds. Fractures that maintain clear dominant directions enable the creation of higher filtration velocities and maintain, or locally feed, the smaller discontinuities. As a consequence of these differential filtration processes, rapid or slow transformations of minerals, washing or deposition of clay minerals and precipitation occur.

Chapter 6

VISUAL AND LANDSCAPE IMPACT

The complexity and scope of the works to restore the ecological system, requires its analysis, with the main goal of restoring the lands degraded by mining activities to the economic circuit. The great efforts required to carry out the actions to improve the environment, to restore the land, to increase the touristic interest is much to be appreciated.

Within the ecological model, the environmental characteristics that are relevant to landscape quality are primarily biological or ecological in nature. The landscape is characterized in terms of plant and animal species present, ecological zones, or other indicators of ecological processes. A major criterion underlying the ecological model is that the quality of the landscape is directly related to naturalness or ecosystem integrity. The validity period of this model depends on the premise that "natural" areas, i.e. areas not affected by humans, are the ones with the highest landscape quality.

At Certej, the setting of quarries and ponds in the landscape proved to be a well-structured ecological model. Regularization of the upper course of the streams that receive mine and quarry waters by constructing concrete channels. The gutters must be built with mini-cascades to oxygenate the water, which will also lead to the precipitation of metal ions in the form of oxides, but also as a landscape aspect framed in the surrounding vegetation.

Tracking the dynamics of the tree stand for reproduction in the forestry circuit is an important factor for the landscape. Thanks to the plant abundance, new ecosystems are created and implicitly a new landscape.

An example is the water from the Valea Mireșului pond, where the population with fish and lake vegetation determined the formation of a new landscape.

These buildings can be played in the tourist circuit of the area, because they have an inestimable value regarding the antiquity and history of the place. Renovated they can be easily integrated into the landscape.

Figure 6.2. Abandoned buildings in Certej

The measures to be taken through this activity are landscape protection measures, established following the identification of the landscape, the finding of dysfunctions and the evaluation of the serious consequences of the identified risks. In order to set up the protection system, it is necessary to go through the following stages:

- defining the purpose of protection;
- ranking the value of landscape elements, on geotopes;
- establishing risk factors and potential hazards;
- the use of the means of protection existing on that date;
- establishing appropriate protection measures for the area;
- establishing the factors responsible for the application of landscape protection measures;

Figure 6.5. Top view of the Certej area (https://adevarul.ro/stiri-locale/hunedoara/certej-blestemul-aurului-din-muntii-metaliferi-)

Wooded hills add context to the landscape, highlighting the contrast between natural areas and those affected by industrial activities. Dense vegetation on the hills suggests a healthy ecosystem, while the eroded area indicates soil destruction and loss of ecological stability.

The visual impact of tailing pond degradation is accentuated by contrasting colors and textures: the vibrant green of healthy vegetation and the grey-brown of exposed and eroded soil. This image reflects the negative effects of industrial exploitation on the environment and the need for remedial measures and protection of natural ecosystems.

Chapter 7

CONTRIBUTIONS REGARDING MINE WATER DEPOLLUTION FROM CERTEJ

There are numerous options available for decontamination of acid mine waters that use chemical or biological mechanisms to neutralize and remove metals from the water. Both biological and abiotic systems include those that are classified as "active" (ie, requiring continuous inputs of resources to sustain the process) or "passive" (ie, requiring relatively few resources to operate). The treatment options are chosen depending on the quality and flow rate of the effluent, but also on the characteristics of the location.

The conventional solution is to collect and chemically treat acidic effluents in a centralized treatment facility. The conventional treatment process is neutralization with lime, which produces an effluent whose quality is in accordance with water discharge regulations and a solid sludge that can be used in dams. After lime treatment the metal hydroxide precipitate particles must grow, stabilize and separate from the treated wastewater. Various reagents can be added to the neutralization process to improve settling. Depending on the chemical composition of the treated water, as well as the compounds that must be removed from the solution, coagulants such as inorganic iron and aluminum salts or polymeric flocculants (polyacrylamides, polyelectrolytes) can be used. In the treatment of acid mine waters, the most used is Percol, a polyacrylamide flocculant polymer. Polymer flocculations form large aggregate particles that resist breakage and settle quickly.

Good results are obtained when using silica solution, a negatively charged inorganic silicate polymer, instead of Percol as the flocculant. Silica sol adsorbs metal species at a pH lower than that of hydroxide formation and acts as a neutralizing agent due to its high alkalinity. However, the process does not lead to the complete precipitation of iron and other metals, in addition, abundant and unstable secondary waste is created.

In the last 20 years, aerobic wetland systems, compost or anaerobic wetland systems, vertical flow wetland systems, treatment ponds, bioreactors and permeable reactive barriers. Some passive systems use limestone dissolution in ponds or channels to neutralize mine waters, but inevitably, the limestone is covered by Fe and Al hydroxides.

In aerobic "weat-land" type systems, oxidation reactions take place and metals precipitate in the form of hydroxides and oxyhydroxides.

Wet-land systems with compost promote anaerobic bacterial activity resulting in sulfate reduction followed by metal sulfide precipitation and alkalinity generation. Passive treatment methods are more common in rehabilitation areas for treating acidic effluents with low metal concentrations and low flow rates. Passive treatment schemes present the advantage of using geochemical and biological processes in order to improve the quality of discharged waters with minimal operating costs and maintenance requirements. Alternatively, effluents can be directed through natural or constructed wetlands, where microbial communities perform the same function. Such a passive treatment scenario meets the definition of sustainability.

Table 7.1. Chemical characteristics of water samples taken from tailings pond exfiltrations.

Parameter	UM	Iaz Mealu	Iaz Mireș	Limit value
				O 161/06 cat II
Indice pH	Unit pH	6,07	6,30	6,5-8,5
Suspensii	mg/dm^3	788,72	832,22	-
Hidrogen sulfurat	mg/dm^3	0,01	0,01	-
Clor rezidual	mg/dm^3	0,00	0,00	-
Azot amoniacal (NH_4^+)	mg/dm^3	0,09	0,07	0,3
Plumb	mg/dm^3	0,005	0,00	0,005
Cadmiu	mg/dm^3	0,000	0,00	0,001
Crom trivalent	mg/dm^3	0,000	0,00	-

Crom hexavalent	mg/dm^3	0,000	0,00	0,05
Cupru	mg/dm^3	0,002	0,00	0,02
Nichel	mg/dm^3	0,002	0,00	0,05
Zinc	mg/dm^3	1,221	1,31	0,1
Mangan	mg/dm^3	0,02	0,02	0,05
Fier	mg/dm^3	2,35	2,53	0,1
Calciu	mg/dm^3	69,83	60,70	150
Magneziu	mg/dm^3	22,58	23,19	25
Fosfor (P)	mg/dm^3	0,00	0,00	0,2
Cianuri (CN^-)	mg/dm^3	0,00	0,00	-
Sulfiţi (SO_3^{2-})	mg/dm^3	0,00	0,00	-
Sulfaţi (SO_4^{2-})	mg/dm^3	1471,29	1589,13	150
Fenoli (7167-92)	mg/dm^3	0,00	0,00	0,001
Substanţe extractibile	mg/dm^3	0,00	0,00	0,1
Detergenţi anionici	mg/dm^3	0,00	0,00	0,5
CBO_5	mg/dm^3	28,88	25,85	5
CCO-Cr	mg/dm^3	59,68	58,49	25

CONCLUSIONS

The mining activity in the Certeje area was particularly developed with the development of a quarry for the extraction of gold ore, the existence of underground mining operations, the existence of a preparation plant and two settling ponds, as well as numerous premises and auxiliary buildings.

The impact due to the activity carried out was significant due to:

- The destruction of large areas of land due to the exploitation of ore in quarries
- Destruction of flora and expulsion of fauna in areas of activity

Heavy metal and sulfate ion pollution of surface water due to discharges of mine water and acid drainage from tailings ponds.

Soil pollution with heavy metals due to acid water discharges and dust deposits resulting from mining activities;

In addition to these significant impacts during that period there were also less important impacts such as air pollution with suspended and sedimentable dusts, combustion gases, as well as noise emissions.

A totally ignored impact is the landscape impact, due at that time to quarrying, the existence of sedimentation ponds, as well as industrial buildings. In addition, there is also an indirect landscape impact due to the construction of housing blocks with a dubious appearance and totally unrelated to the specifics of the area.

In 2009, works began to close the Certeje mine, during which the sedimentation ponds were partially arranged and a series of industrial buildings were demolished.

During the completion of the closure works, a reduction in the degree of water pollution from acid drainage and a reduction in the landscape impact was observed.

Part of the Certeje mine closure works were abandoned in 2012.

In my doctoral thesis I evaluated the residual impact existing after 2016;

We determined the potential to generate acid mine waters by the ABA test and found it to be reduced for material deposited in tailings ponds.

The waters resulting from the exfiltration of sedimentation ponds have relatively low concentrations of heavy metal ions and a high content of sulfate ion.

Due to the low concentrations of heavy metals, their removal by precipitation is difficult due to the small volume of the precipitate. It is found that a large volume of acidic waters should be purified, for the reduction of relatively small concentrations of heavy metals.

The use of reverse osmosis has been proposed for the purification of acidic waters. The results obtained experimentally are very good, allowing to obtain permeates that fall within the legal limits for discharging into surface waters and a concentrate that can be easily purified by the classic processes by treatment with lime or limestone.

The presence of the calcium ion next to the sulfate ion favors the formation and deposition of calcium sulfate crystals on the membranes, which considerably worsen the production capacity of the reverse osmosis columns.

At low temperatures this phenomenon is insignificant, but at high temperatures antiscaling reagents must be used or reverse osmosis columns with cleaning devices must be used.

As the tourism development of the area is increasingly desired, the landscape impact remains the most important after the cessation of mining activity and the completion of closure works.

The landscape impact is due to the existence of the quarry and the sedimentation ponds, but to the greatest extent to the industrial buildings, in various stages of decay, and to the existence of housing blocks which, in addition to an inadequate appearance, do not fit into the specifics of the area.

Future directions

Identifying some methods of reducing the residual landscape impact so as to create the conditions for the development of tourism.

Identification of possibilities for the recovery of heavy metals from the concentrates resulting from the reverse osmosis process.

Due to the fact that a new mining operation brings the area to the stage where it left off in terms of the major impact of all environmental factors, a bioremediation through phytomining is proposed.

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