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# Ecological Rehabilitation of Areas Affected by the Mining Activity

Emilia-Cornelia DUNCA [1]

Conf.univ.dr.ing., Faculty of Mines, Department of Environmental Engineering and Geology, University of Petrosani, Romania, *emiliadunca@upet.ro*

**Abstract:** The paper presents a possible strategy for the environmental rehabilitation of mining areas during the transition to a market economy. Rehabilitation of the environment affected by extraction and processing activities becomes a costly problem that is both difficult to achieve in the short and medium term. For the ecological rehabilitation of a mining perimeter, it is carried out: identification of the sources of pollution; systematic analysis of all environmental components, highlighting major environmental issues; harvesting and determining the mineralogical, petrographical, physical, mechanical and chemical properties of environmental components; performing stability calculations for tailings deposits; performing a complex and complete impact analysis; proposing solutions for ecological rehabilitation. Monitoring of environmental components in the mining perimeter is necessary because it is possible that pollution persists in these areas. The paper finishes with three case studies from the country and abroad of ecological rehabilitation.

**Key words:** *ecological rehabilitation, impact, mining perimeter, tailings, monitoring*

## Introduction

The mining activity through its specific nature produces multiple and various negative effects on the environment through: relief changes; occupying large areas of land; land degradation; pollution of surface water and groundwater; hydrodynamic imbalance of groundwater; negative influences on the atmosphere, flora and fauna in the area; chemical soil pollution, which can affect for many years its fertile properties; noises, vibrations and radiation spread to the environment, with a strong unfavourable action. [9]

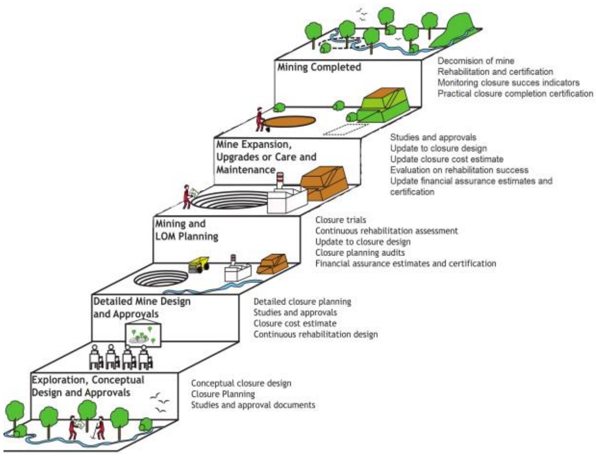


**Fig. 1.** Phases of a mine's life cycle [14]

The mining life of a mine includes the exploration, exploitation, mining, ecological rehabilitation and post-closure phases (fig. 1).

Due to the ore exploitation activity, more than 550 waste dumps have been built in Romania, covering an area of approximately 800 ha and storing more than 200 million m$^3$ of the tailings.

At the level of the two Hunedoara and Gorj counties, it can be noticed that the number of tailings dumps and tailings ponds in conservation is in a large percentage compared to those that have been ecologically rehabilitated. (Table 1 and Table 2)

**Tabele 1.** Situation of tailings and tailings ponds in Hunedoara County

| Deposits | Total nr. | Surface (ha) | Active | Conservation | Rehabilitation |
|---|---|---|---|---|---|
| Wate dumps | 42 | 360 | 6 | 36 | 0 |
| Ponds | 15 | 315 | 2 | 12 | 1 |

**Tabele 2**. Situation of tailings and tailings ponds in Gorj County

| Deposits | Total nr. | Surface (ha) | Active | Conservation | Rehabilitation |
|---|---|---|---|---|---|
| Wate dumps | 463 | 4000 | 20 | 200 | 243 |
| Ponds | 1 | 4,51 | 0 | 1 | 0 |

**Impact of mining on the environment**

By its specificity, the entire mining activity has a significant impact on all environmental components from the exploration to the closure and ecological rehabilitation phase. [9] (fig. 2)

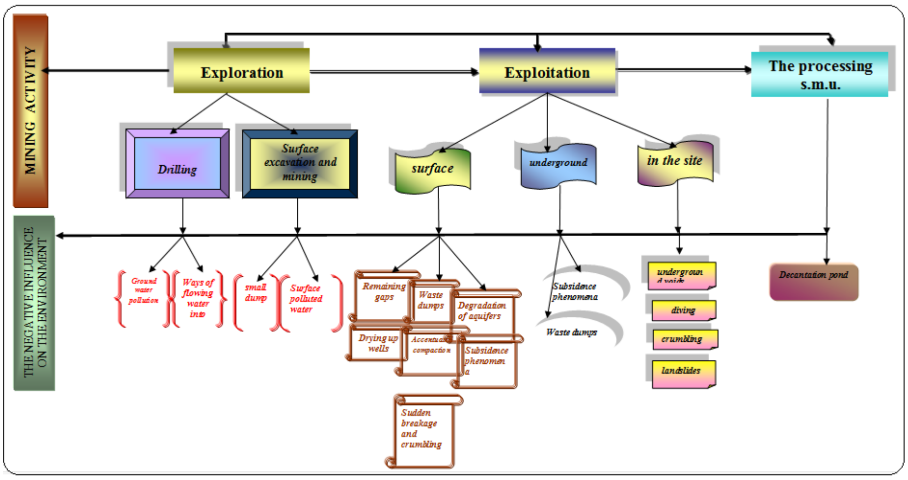


**Fig. 2.** The impact of mining activity on the environment

The negative effects of mining activity are manifested both locally and zoned on the environment through: an unpleasant visual impact; degrading and occupying large areas of land for a very long time; pollution of surface or underground water with dissolved chemical elements or suspensions of solid particles entrained from dams by rainwater or infiltration; air pollution with gases from minerals contained in ponds or produced by their oxidation and combustion; material and human destruction due to the loss of stability. [4-6]

Waste and debris within the mining perimeter contributes to the soil pollution process directly or indirectly by polluting the water from both rainfall and lateral spills that infiltrate the soil. The storage of various residues has affected soil morphological and physical-chemical properties.

The impact of mining activities is a local and area impact on surface and long-term volumes and refers to: the physical-chemical imbalance in the basement produced by excavations and dumps also extends to the areas near the mining perimeter; disturbance of the physical-chemical equilibrium of the geological environment produced by geological, hydrogeological and geotechnical prospecting through drillings with insignificant, inevitable and irreversible effects on groundwater and groundwater systems, on small surfaces and volumes and in limited time; soil and subsoil damage through building, road, infrastructure and mining mass, etc.; destruction of the natural geological environment; the soil layer is recovered from agricultural land but can not be recovered from deforested forest land and as a result it is destroyed; rock layers are deployed, transported and stored on sites down to the tens and even hundreds of meters; the resulting, sterile and useful mining masses acquire geotechnical features other than basic rock; the deposited tailings create new compaction and stability effects on new sites.

To assess the global impact of mining activities on the environment, we will determine: *quality indices (Qi)* on environmental components, (rating scale labelled 1 to 10 for values Qi); pollution indices (*Pi*) on environmental components (credit rating scale 1 to 10 for values Pi) and the global pollution index (GPI). [6]

The risks of accidents or damages that may have a major impact on the environment or on the population are: fires or explosions at the explosives store, leading to damage to the ecosystem in the area with harmful effects on environmental factors; loss of stability of tailings dumps; loss of stability of tailings ponds; the accidental discharge of sterile sludge from the pond into the nearby rivers. The risk is calculated by the formula (1):

$$R = P \times G \qquad 1)$$

where: P - probability factor; G - gravity factor.

The overall assessment of the environmental impact of the useful mineral exploitation activity is done using an impact assessment matrix tailored to the specificity of the exploitation activity.

The advantage of using the matrix lies in the fact that the main and related actions of the exploitation activity with the environmental factors and conditions existing in the mining perimeter and the surrounding impact area, at the present and future of the activity are put forward.

**Ecological rehabilitation**

The ecological rehabilitation of a mining perimeter also requires stopping pollution sources and reducing the effects of pollution on the affected environmental components. For any rehabilitation work it is necessary to know the situation before the degradation. For the already attacked areas one can study a neighbouring area or another with similar ecological characteristics. [6]

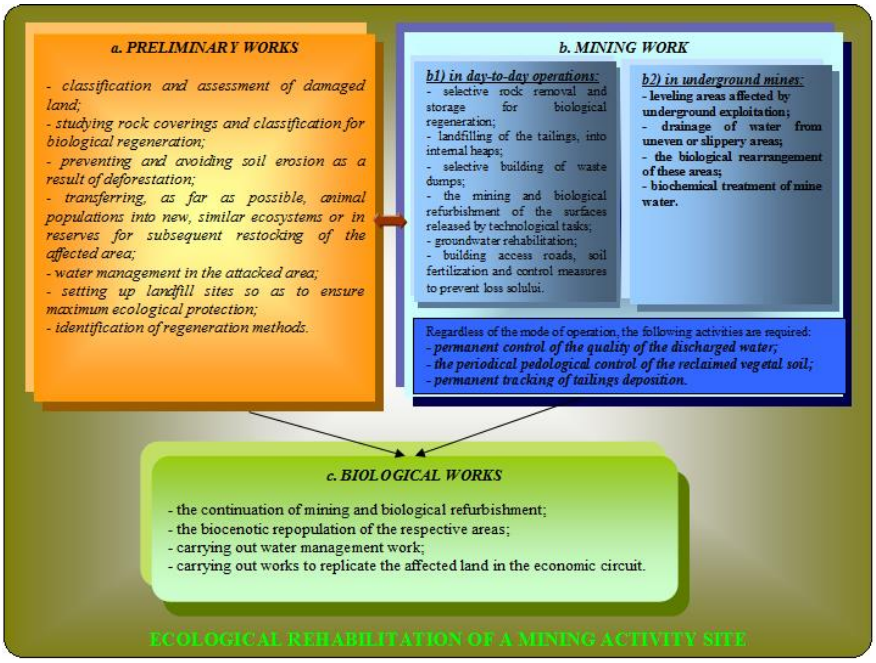


**Fig. 3.** The groups of works needed in the ecological rehabilitation of areas affected by mining

The ecological rehabilitation project for a site affected by a mining activity, such as the one covered by this study, should comprise three groups of works: *preliminary, mining and biological*. (fig. 3)

**Rehabilitated mining environment monitoring**

An effective monitoring program should take into account the three approaches: *visual verification, prospecting and/or sampling and instrumentation.* Monitoring points shall be located in, or near, areas affected by the development and / or rehabilitation program.

| The mining activity and its components | Problems tracked | Potential monitoring methods |
|---|---|---|
| THE MINE | | |
| - Shaft/galleries<br>- Drains (drainage channels) | - acid solutions<br>- rhe reagents to prepare the rambrele | - Collecting and analyzing groundwater drainage and surface |
| QUARRY | | |
| - Steps<br>- Water collection points (from quarries and from the surface) | - acid solutions | - Collecting and analyzing drained water in the quarry and the meteoric ones |
| POCESSING PLANT | | |
| - Grinding<br>- Flotation<br>- Amalgamation<br>- Pipeline transport of slurry | - alkaline solutions<br>- rhe reagents to prepare<br>- heavy metals<br>- the sterile slurry | - Collection of samples and water analysis<br>- Collection of samples and waste analysis |
| DUMP AND TAILINGS DAM | | |
| - Residues / alluvium<br>- Dams | -acid solutions<br>- the reagents to prepare<br>- heavy metals<br>- the sterile slurry | - Collection of samples and water analysis<br>- Collection of samples and waste analysis<br>- Analysis of infiltration water |
| MANAGEMENT OF WATER RESOURCES | | |
| - Leaks / infiltrations<br>- Evacuation / draining<br>- Dams / channels | - changes in water quality<br>- environmental impact assessment | - Collection of samples and water analysis |

Monitoring should pursue physical stability including the effects of static and dynamic conditions and chemical stability, including prevention, migration and control measures. [7]

**Ecological rehabilitation of mining sites in the country and abroad**

**Case Study - Study and Safety of the Triangle de Marienau TMF. Possible proposals for treatment and rehabilitation**

In the Masters degree in Treatment and Evolution of Industrial Change, we have been conducting a 6-month internship in the Closed Mining Managing Department at Charbonnages de France. [7]

The theme of the study was to solve the problems of securing and eventually rehabilitating the Triangle de Marienau decanting pond used for the storage of residues from the Marienau coke plant.

Managing a site within polluted soils is based on estimating the effective environmental risk, particularly for human health and groundwater quality, depending on site use. The main principles for polluted sites and soils can be summarized as follows: know, prevent, treat / rehabilitate.

The „Marienau Triangle” site is located at the confluence of the Rosselle and Morsbach valleys and therefore geologically relies on recent alluvial deposits consisting of fine and / or coarse sand with local lentils of peat and peat can reach several meters in thickness (fig. 4).

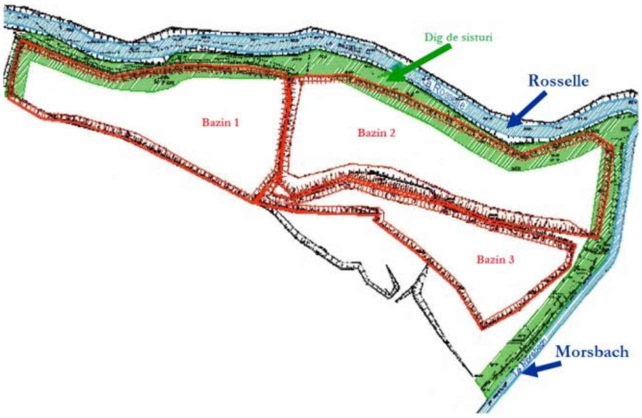


**Fig. 4.** The „Triangle de Marienau" tailings pond with the three storage basins

The land is made up of sludge sandy, which can lead to a deep transfer of pollutants. In 2004, the groundwater was 100 m deep and flowed to the piezometric funnel of Marienau. After stopping groundwater pumping in 2014 at an average puviometric regime, the groundwater rose in about 10 years and the flow direction changed to the Rosselle River. [7]

Two sections were fed through the TMF. In the first section, it can be noticed that the future hydrostatic level will not cause problems after the drainage of the mine as the water will not flood the basin 1. The underground water will be installed in the alluviations below where there is the possibility of finding the already migrated pollutants.

The second section shows that basins 2 and 3 could be in contact with the aquifer under exceptional precipitation conditions. The soils are made of alluvium, sand and gravel. As a result, a leaching mechanism could be envisaged leading to a profound pollution transfer. If there was a transfer of pollution, it would only refer to the superficial layer of alluvial matter (fig. 5).

For the treatment and eventual rehabilitation of the site, the following activities are required:

**Inventory of the industrial site by**: observing and identifying the pollution of the site; site history study if the activity has produced pollution; study on surface water that crosses the site.

**Soil and groundwater study** is carried out in two stages:

**Stage A**: site history analysis, pollution vulnerability study, site technical visits.

**Stage B**: Additional information, such as that from some field investigations.

**5.2. Case study - Ecological rehabilitation study of areas affected by mining activity in the Brad perimeter**

In the PhD thesis entitled **„Ecological rehabilitation study of areas affected by the mining activity in the Brad perimeter",** we approached a topic of utmost importance for the human communities in the vicinity of the mining areas in order to rehabilitate them ecologically. [6]

The exploitation of gold-silver ores in the Barza mine took place in the Barza mine, located in the Barza village, Crişcior commune, about 6 km S-E from the city of Brad. The extraction of the copper miner in the Morii Valley Quarry, located on the territory of Crişcior commune at approx. 7.0 km S-E from Brad. [6]

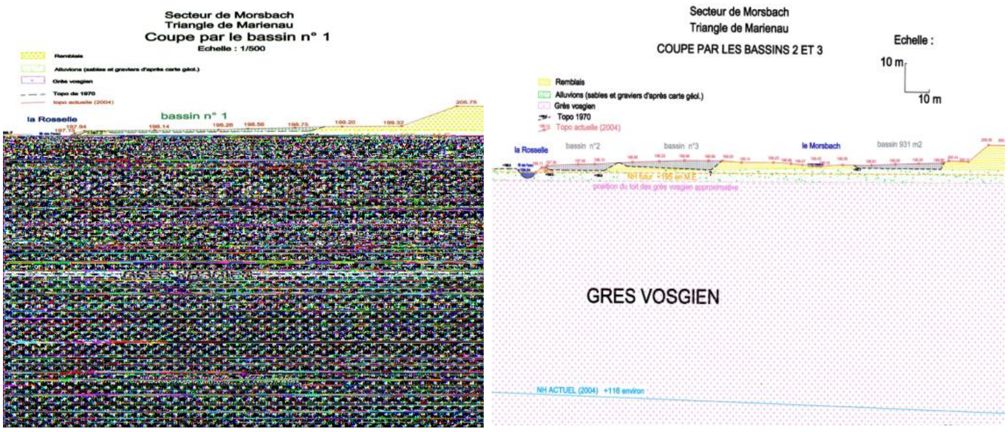


**Fig. 5.** Cross sections through the „Triangle du Marienau"

The exploitation of gold-silver ores in the Barza mine took place in the Barza mine, located in the Barza village, Crişcior commune, about 6 km S-E from the city of Brad. The extraction of the copper miner in the Morii Valley Quarry, located on the territory of Crişcior commune at approx. 7.0 km S-E from Brad. [6]

Gold-silver and copper ore production plants are located in Gurabarza on the territory of Crişcior commune, about 5 km away from the city of Brad.

The sill resulting from the exploration works in the Morii Valley Quarry was deposited in the Cireşata damp, and the resulting from the underground opening and exploitation works in the Barza mine in the Blojului Valley, and the tailings from the Gurabarza preparation works in the settling dam in Ribita, located at about 6,5 km V-NV from the town of Brad on the territory of Baia de Criş village Ribita village (fig.6). [4]

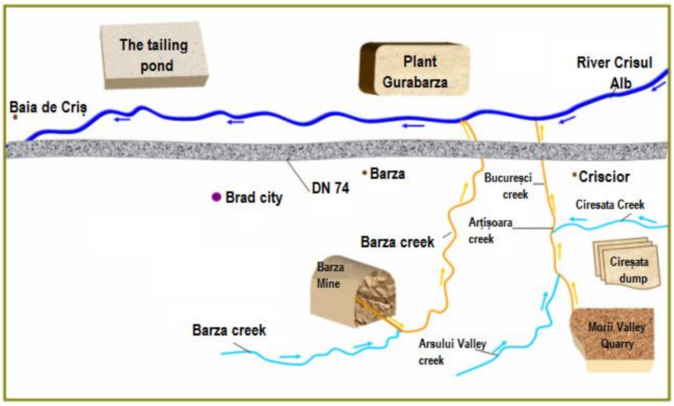


**Fig. 6.** Mining Objects in the Brad Perimeter

The exploitation method used in the Barza mine was *„Horizontal Slicing with Cameras and*

*Folding Slices”*. This method of exploitation has the most modest technical-economic performances, the productivity of working at abatement 1.8 ÷ 5.2 t/post; average production on abseil 550 ÷ 2000 t/month; dilution 7 ÷ 23%; losses 10 ÷ 12%.

The Morii Valley Quarry activity is stopped although there is an approved reserve of 21.3 million tons which could provide for a program for the extraction and processing of copper ore for over 35 years at a production capacity of 650.000 t/year. [6]

As a result of the ongoing activities within the Brad Mining Branch, there are pollutants that affect the environmental factors: water, air, soil, flora, fauna and human settlements.

In order to constantly monitor the quality of the environmental factors we have placed harvesting points according to fig. 7. These harvesting points were located both upstream and downstream of the sources of pollution.

The water environment factor within the Brad perimeter is affected by the mining and quarrying waters discharged from the underground through the 1 May respectively from the quarry and the wastewater discharged from the Ribita-Curteni TMF. (fig. 8)

Thus, the waters discharged from the underground through the 1 Mai Gallery alter the physical-chemical and biological characteristics of the Barza brook in which they are discharged. Based on the determinations made, we obtained a variation in the concentration of the various indicators analyzed. Laboratory analyzes showed high Mg, Ca, Cu, Fe and pH values, with pH values between 2 and 3. [3-4]

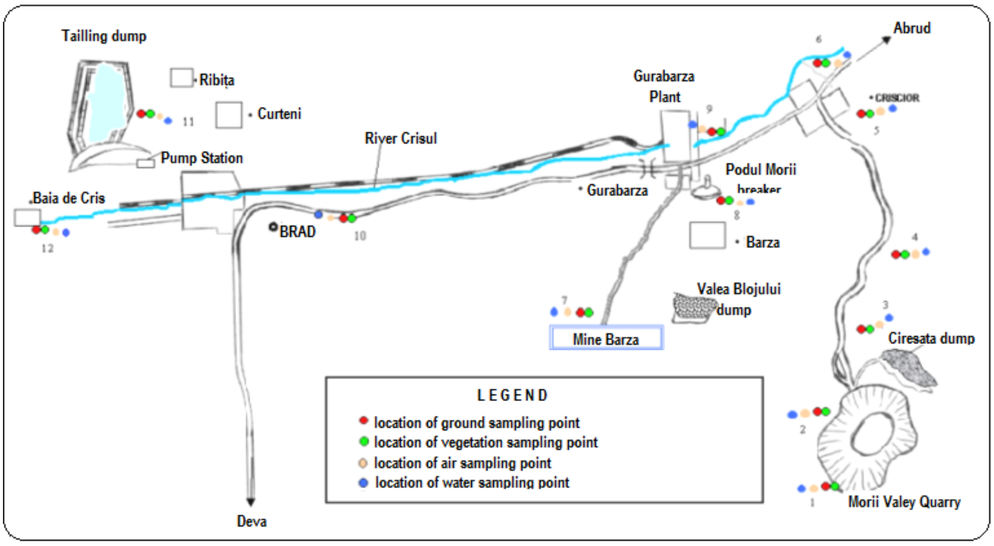


**Fig. 7.** Sampling points for water, air, soil and vegetation [6]

The entire activity carried out in the Brad mining perimeter has an impact on soil quality in the area by loading the soil with heavy metals, the occurrence of non-evolved soils, reducing the amount of humus in the horizons with the analyzed soils, reducing the fertility of the agricultural lands (Figure 9). The high content of heavy metals recorded in the perimeter studied is the result of both the general pollution of the area and the specific activity within the branch.

**Fig. 8.** The environmental factor affected by the quarry and mine waters in the Brad mining perimeter

Air pollution in the Brad mining perimeter is carried out on small areas in the areas where the mining activity takes place, by: transporting the ore from the mine mouth to the Podul Morii; crushing the material and transporting it with conveyor belts in the preparation plant; the gold-silver ore production technology at the Gurabarza preparation plant; the Ribita tailings pond - active and tailings dumps not covered with vegetation.

The potential environmental impact is maintained throughout the exploitation period of the reservoir, manifested by a zoned pollution with sedimentary dusts in extreme weather conditions, such as droughts and strong winds, when large solids can be trained and transported over large distances quarry, pits, pond, crushing of ores affects the inhabitants of neighbouring areas, causing discomfort to the population.

The major objectives for the ecological rehabilitation of Brad are as follows:

- ✓ decontamination of mine, quarry and tailings discharges, etc.: mine water management; management of the quarry waters.
- ✓ rendering degraded lands into the economic circuit: heaps, ponds, etc.;
- ✓ valorisation of tailings deposits;
- ✓ improving the health of the population.

**Fig. 9.** Soil pollution through tailings and tailings pond in the Brad mining perimeter

One of the solutions for mine water abstraction in the Brad Mining Perimeter is to capture the mine waters in the 1 Mai Gallery and guide them through a pipe to the Gurabarza preparation plant where it is mixed with the sterile slurry discharged from the preparation plant and then together will drive through pumping using Warman pumps to the Ribita decantation pond. From the pond, after clarification, the waters will be directed to the chemical treatment plant of the pond, where metal ions can be removed by lime precipitation (Figure 10). [5]

Mine management means, first and foremost, the prevention and combating of their harmful effects on aquatic ecological balance, on terrestrial vegetation, and last but not least on humans.

In the mining activity of the copper mine in the Morii Valley mine no water was used, so the surface water pollution takes place only in rainy periods. The flow of rainwater is not constant or permanent; it influences the surface water quality in the area of the quarry all year round. [6]

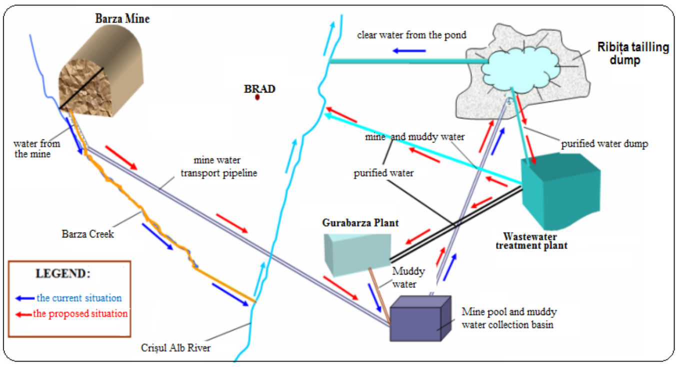


**Fig. 10.** Mining water capture and depollution in the sewage treatment

For the waters of Morii Valley Quarry, which result from the washing of the berms and the slopes of the steps by the rainwater and flowing directly into the Valea Arsului brook, and those on the Cireşata pits in the Cireşata Valley brook and then flowing into the brook Bucharest all the tributaries of Crişului Alb, I proposed the following solution: the capture of the two brooks, namely the Arsului Valley and the Cireşata Valley, in the collecting and purification basins in a purification plant, after which it will flow into the Artişoarei Valley.

As a measure to prevent the contamination of the purged water discharged into this brook, it is proposed to excavate the brook of the Bucharest stream (Figure 11). [3]

Two capture basins will be built to capture the two brooks. When calculating the two basins, account shall be taken of the amount of precipitation falling within 24 hours taking into account a heavy rainfall.

According to the norms of labor protection, the water collection must be made only in specially designed buildings, the minimum capacity of which must correspond to the flow of water to be collected over 12 hours at their normal affluence.

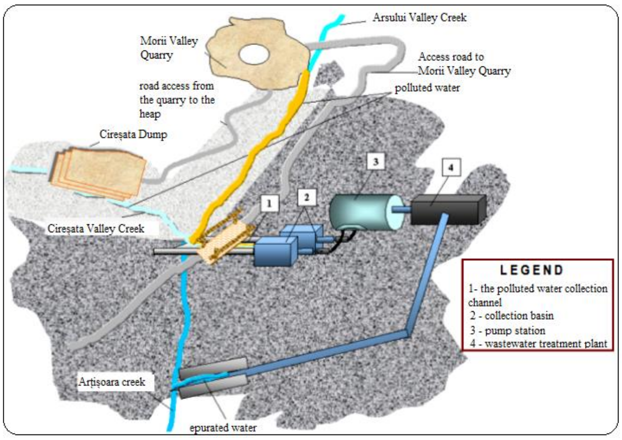


**Fig. 11.** The catchments of the Arsului Valley Valley and the Cireşata Valley and their purification

Drainage (maximum flow) depends on the amount of precipitations that have fallen, the amount of water retained and infiltrated, and the size of the surface on which the leak occurs.

$$Q_{max} = \frac{10 \cdot S \cdot h \cdot k}{t \cdot 60} \qquad (1)$$

n which: $Q_{max}$ - maximum flow rate, [$m^3/s$]; t - rainfall duration equal to water concentration time, 24 [hours].

The maximum values of torrential rainfall dropped within 24 hours at the Vladeasa weather station are calculated as representative for calculation:

h = 58.8 mm / day; S = 20 ha; k = 0,4.

$$W = 10 \cdot S \cdot h \cdot k = 196 \ m^3/h = 4.704 \ m^3/day$$

$$Q_{max.} = \frac{10 \cdot S \cdot h \cdot k}{t \cdot 60} = 0{,}021 \ m^3/s = 75 \ m^3/h$$

In order to render in the economic circuit of the tailings deposits, it is necessary to perform a verification of their stability under geological, hydrogeological, natural, geomechanical, anthropogenic (technogenic), hydrometeorological, seismic and biotic factors acting on these deposits (Figure 12). [5]

When carrying out the biological recultivation works of the tailings deposits in the Brad

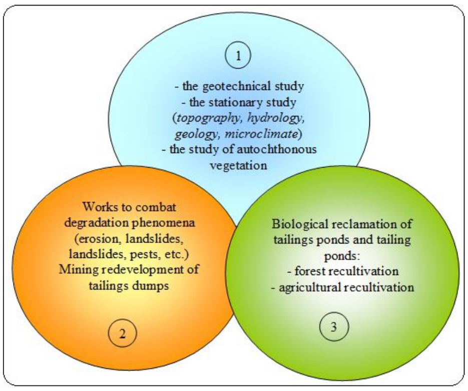


**Fig. 12.** Playing the tailings deposits in the economic circuit

mining perimeter, a field study of the negative phenomena encountered on the tailings dumped in the study was carried out.

When installing artificial forest vegetation, the choice of wood species is a fundamental issue of the greatest importance. In general, the choice of species must be made in order to ensure the polyfunctional character of the crops.

In order to ensure the necessary concordance between the bio-ecological requirements of the species and the static conditions, criteria of common choice are used irrespective of the main role assigned to the forestry culture. To this end, account shall be taken of the indications given by the basic type of forest, the type of resort.

For the installation of forest crops in degraded land, it is mainly aimed at the consolidation of land and soil improvement (Figure 13). To this end, priority shall be given to arboreal and arbustic species of high ecological amplitude. Of these, it is preferable to those with vigorous growth, strong rooting and well-developed canopy with rich foliage.

By the afforestation of the tailings deposits, the surface runoff rates will be reduced, as well as the phenomena of surface and deep erosion

A long-term monitoring program implemented during the development of the Brad mining perimeter and continued until closure will reduce the frequency of work of the samples after closure, while in case of decommissioning this frequency should increase. Whenever there are significant changes in environmental conditions, additional monitoring will be introduced. [4]

In the Brad area, which is the subject of this study, an impact monitoring system should be set up to establish environmental pollution. The three environmental factors studied are water, air and soil, but flora and fauna can also be included.

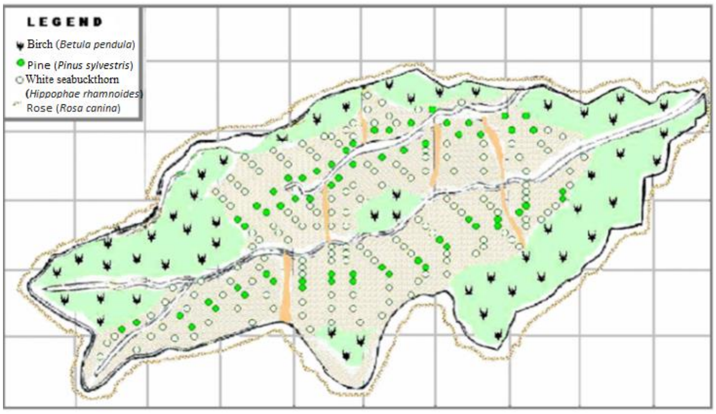


**Fig. 12.** Biological recultivation of the Cireşata dump

Figure 14 shows the Brad area where monitoring is highlighted by the location of observation points in sensitive areas. Monitoring points are located both upstream, but especially downstream of each mining perimeter taken into the study. [6]

At the environmental quality control station there is the data grouping, the interconnection and comparison of the information obtained by different specialists, the removal of errors, the control of the way the monitoring takes place.

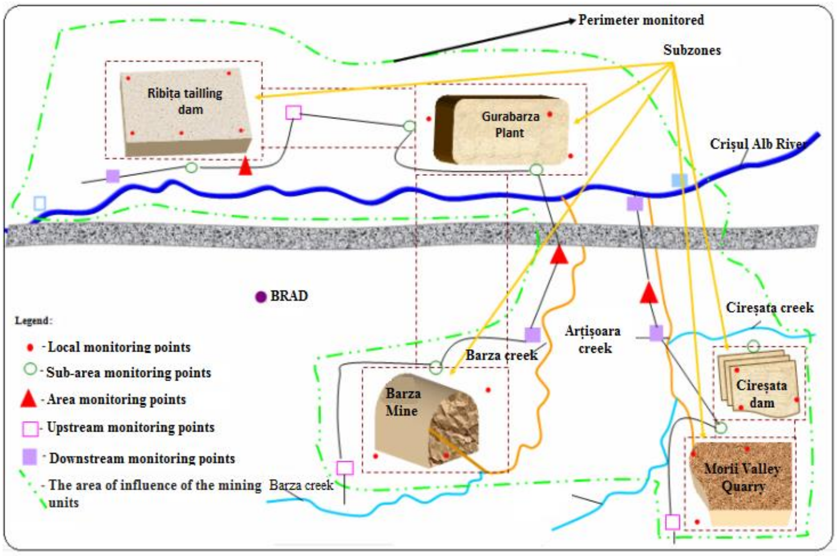


**Fig. 14.** Brad Mining Area Monitoring

## Case study - Possibilities of environmental rehabilitation in the Mătăsari mining area

This study attempts to synthesize the specificity of the Jiu Mining Basin (changes induced to the support and the immediate area by the construction of the Bohorelu tailings dumps) and how the degraded territories can be functionally reintegrated (management model integrated). [12]

The natural modelling and the agricultural use of the Bohorelu dump have led to the sculpting of the rectangular artificial morphology resulting from the construction of the technostructure, thus the construction stages are no longer noticeable (Figure 15).

The construction of the heap at the Bohorelu Valley has led to important

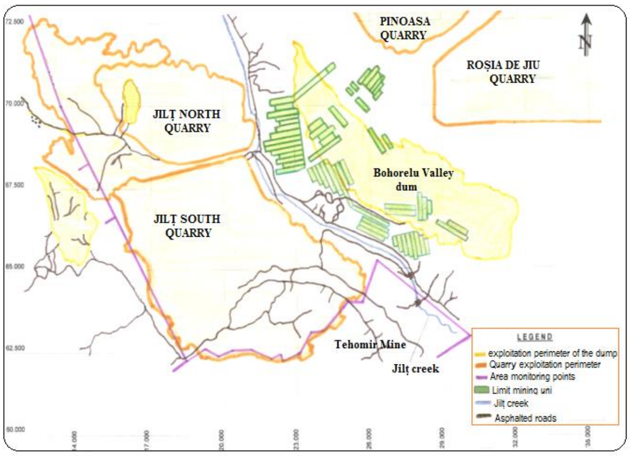


**Fig. 15.** Mining basin situation plan Jilţ

changes in the local geomorphologic system. By analyzing the concrete situation on the ground, we were able to identify the main effects felt at the local level:

- using parasites for the horizontal meadow morphology with a horn structure of anthropogenic origin with a chaotic microrelief (morphological and morphometric changes, aspect of heterogeneous landscape with unsightly accents, becoming by integrated greening to the local context etc.).

- changing land use from the Jilţ meadow. The fertile soil of the meadow was replaced by a hilly area with poorly productive protisol, still susceptible to degradation. Thus there was a deterioration of edafic potential, with implications both for the reduction of agricultural activities and for the substantial replacement of the original meadow vegetation with vegetation of weeds and inferior plants.

- triggering the contemporary geomorphological processes on the surface of the dump and its neighboring areas as a result of changing the local balance. Thus, there appeared: superficial landslides (on the stairs and slopes of the heap), pluviodenudarea and drainage (due to the sandy substrate), pseudosolifluxions (in the bermage area and at the top of the heap), compaction (on the flattened surfaces, compaction of the heap), muddy flows (on narrow surfaces, very high precipitation and against the background of some preliminary landslides), wind erosion (in the construction phase, caused the dusting of the Jiţ area). [12]

- the modification of the hydrosphere components, as follows: the groundwater has undergone changes (both in terms of qualitative and quantitative components), the hydrogeological dynamics undergo local changes, the surface leakage and the meteorological water filtration ratio has changed substantially (the consequences observed in the bed: increase of the high flow rate, raising of the anastomosis tendencies, over-dimensioning of the slurry cones, etc.) occur in the heap of the heap (due to the poor drainage), etc.

- changing the local climatic conditions by generating a specific topoclimate (barring the air flows from the Jilţ corridor, etc.).

- changing the range of natural color shades (green, green, rusty, brown, gray, yellow, etc.) with the shadows of the dressing material (red, gray, yellow, black-gray, brown-red, etc.). The effect was alleviated by greening.

- the impossibility of developing the public space in the heap deposit sector as a result of the instability of the structure.

- degradation of the natural elements of the areal area (soil, running water, groundwater, visual pollution, etc.)

- changing the infrastructure of the territory by creating access roads for machinery and depositing tailings in the dump, degrading the existing roads, etc.

So there was a strong change in morphology and morphometry; flora and fauna; the pedological and hydro-atmospheric component, etc. on the entire Jilţ corridor between Mătăsari and Motru.

The way in which the activity carried out in Mătăsari basin affects the environmental factor of water does not consist mainly in emissions of pollutants in water, as in the radical intervention on the permanent and torrential water courses as well as the underground water of the water meter by altering the relief, the creation of a drainage regime appropriate to the „state" of the work fronts and, consequently, the creation of an inflow of surface water from the drainage, which are led to the nearest final emissary, the Jilț brook.

The tendency of returning waters to the initial position due to the dynamic inflow from the depressed area requires the existence of a drainage system - follow-up, on definitive steps to check the behaviour of the slopes, heaps and volume of infiltrations in the area (Figure 16).

**Fig. 16.** Drainage channels destroyed the Bohorelu outdoor heap and accumulations of water at the base of the quarry

Due to excavations and consecutive shifts, water courses in valleys disappear; At the same time drainage of the waste dumps leads to other non-existent water courses. Also, through infiltration or accumulation of precipitation water in unplored depressions after excavations, higher or lower accumulations are created which in time turn into lakes that can serve for fish farming or irrigation. [12]

Exploiting the agricultural potential by encouraging alternative crops of rape, in order to provide an alternative fuel source for tractors and self-propelled agricultural machinery, is a current energy desideratum with broad development prospects.

The Bohorelu tailings pond occupies an area of 860 ha, currently an active dump. Approximately 46 hectares were reproduced in the economic circuit through acacia plantations (about 26 ha), agricultural crops (corn and wheat) but also spontaneously hunted for grazing livestock. The area of 820 ha is currently not released from technological burdens because it is still being dumped.

According to expert estimates, the exploitation of the two quarries will end in less than 20 years, so tailings dumps can constitute a new green fuel reserve.

In this paper I propose as a solution for ecological rehabilitation, the cultivation of the Bohorelu valley with maize, wheat and rape, through their rotation, to achieve natural soil fertilization at all times (fig.17). From rape, biofuel is an alternative to lignite extraction.

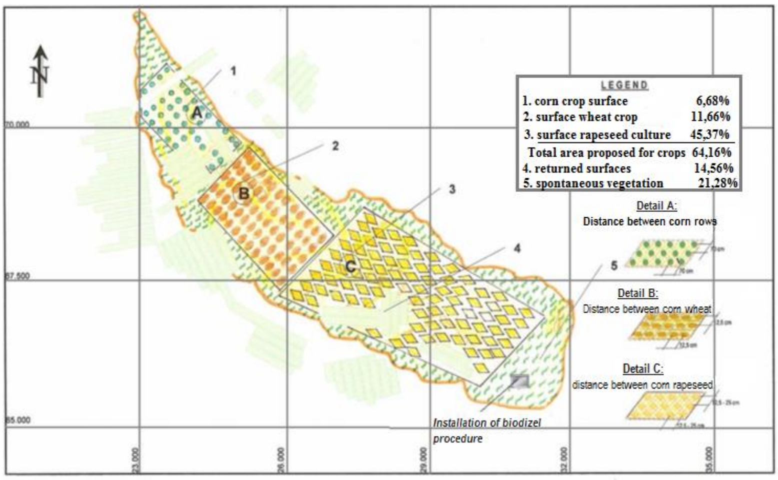


**Fig. 17.** The location of the crops on the Bohorelu valley

The North Jilts Quarry has a hilly relief with the same characteristic of the South Jil, but a little more rugged, with a difference of 170 m between the maximum and the minimum land, for ecological rehabilitation it is proposed to create a motocross track.

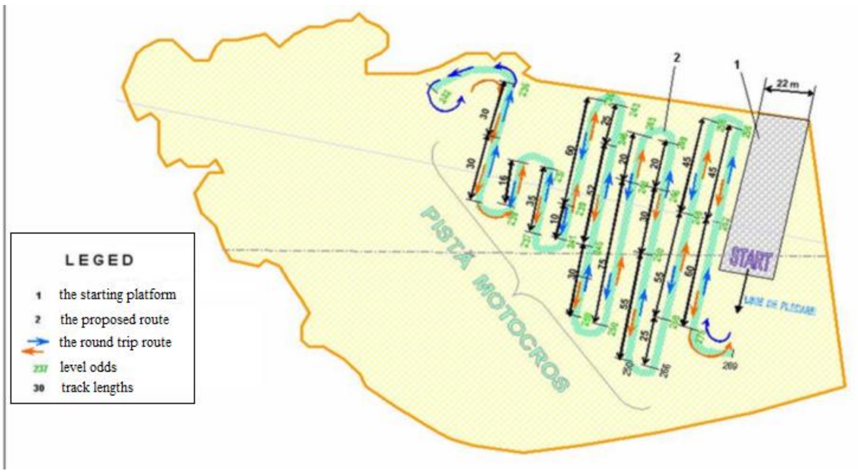


**Fig. 18.** Route of the motocross track in Jilţ Nord

The paper presents a possible strategy for the environmental rehabilitation of mining areas during the transition to a market economy. In parallel, sources of funding for these areas should be found, called a system of responsibilities and an estimation of the importance of funding, which is normal to be imposed on those responsible for pollution.

The rehabilitation of the affected environment in the mining perimeters through the extraction and processing of useful minerals becomes an issue as expensive as it is difficult to achieve in the short and medium term.

## Conclusions

-In carrying out the ecological rehabilitation works of the areas affected by the mining activity are necessary:

-chemical analysis of the stored material;

-water quality upstream and downstream of these deposits;

-installing piezometers to monitor groundwater quality;

- the location of a survey network to determine precisely the quality of soils and material stored in the three ponds;

- conducting laboratory leaching tests on the material;

- sampling of alluviums under this deposit;

- sampling soil samples at a distance of 5, 10, 15 and 20 m from the site, in the direction of groundwater flow;

- the location of two piezometers, near the three pools and one near the second pool;

- use of a specialized software to rehabilitate polluted sites to facilitate research and to find solutions in the shortest possible time;

- using a site-based biological method to reduce pollution to total disposal if possible;

- study of the physical-geographic and ecological factors of the resorts delineated on the deposits under study;

- after planting saplings, a series of care works are required until they reach maturity;

- the closure of the massif in a short time leads to the integration of the tailings deposits into the landscape but also ensures a higher degree of stability.

- by the afforestation of the tailings deposits the surface runoff rates will be reduced and surface erosion phenomena will be stopped;

- the restoration of the fauna in the affected areas will lead to the restoration of degraded ecosystems by the mining activity;

- by creating a regional monitoring network, it will be possible to monitor and control the impact of mining and intervene to stop pollution;

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