IDENTIFICATION AND ASSESSMENT OF THE ENVIRONMENTAL IMPACT GENERATED BY THE IMPLEMENTATION OF CERTEJ MINING PROJECT

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Abstract: *Extractive industry, regardless of how it is performed, always leads to long term negative effects on the environment. The environmental component that suffers the most as a result of mining activities is land, and with it the entire ecosystem in the area. The most significant destructive effects of open pit mining are produced, both by the quarry and the associated waste deposits and tailings ponds. Removing the overburden and extracting minerals from an ore deposit constitutes a destructive action, with possible repercussions on local or regional habitats and fauna. These effects can be extremely serious if they interact with natural environments of high value. The effects are obvious when mining operations are performed using explosives and mechanical equipment through noise, large amounts of dust released in the atmosphere, causing major damage to vegetation and problems related to irreversible alterations of habitats (physically, chemically and biologically), with consequences in both the project area and adjacent areas. Storage of tailings from processing activities (in which the mineral material is often associated with dangerous toxic substances) in ponds, may cause functional alterations or destruction of the territory in which they are located. Given the above, based on preexisting data and field observations, the paper aims at making an assessment of the possible consequences on the environment (using three methods, namely: checklists, impact matrices and impact networks) that may be generated by the implementation of a large-scale mining project, being taken as a case study the Certej Mining Project (exploitation and recovery of the sulphide epithermal gold-silver ore deposit quartered in the Metaliferi Mountains).*

Key words: *impact assessment, mining, quarry, tailing ponds, waste dumps*

INTRODUCTION

Certej mining perimeter is located according to the technical sheet, on the administrative territory of Certeju de Sus commune, Bocşa Mică village, approx. 20 km northeast of Deva city.

Certej ore deposit is part of the "Golden Quadrilateral" Săcărâmb - Brad - Rosia Montana - Baia de Aries, an area which produced between 1,000 and 2,000 t Au, since pre-Roman era. Historical information about Certej deposit dates from the seventeenth century, when the mining operations were done using rudimentary methods (RSG, 2007).

Certej ore deposit is classified as an intermediate sulphide epithermal deposit because Au it is associated with Ag, Pb and Zn and to a lesser extent with Te and As. Mineralization footprint has a general E-W orientation and is limited between two major fault lines oriented NW-SE (east and west fault lines).

According to currently available data, three objectives of the project (two tailing ponds with the related dams and the andesite quarry) overlap on the Metaliferi Mountains Natura 2000 ROSPA0132 site. The footprint of the mining project overlaps on 108.7 ha, about 0.4% of the Natura 2000 site, on Macrisului Valley (figure 1) (HODOR ET AL., 2013).

Other reservations of national interest (Limestones from Magurile Băiţei, Bholt Reservation, Magura Săcărâmbului, Măzii, Glodului and Cibului Gorges) are located at relatively small distances from the project area, between 3-13 km.

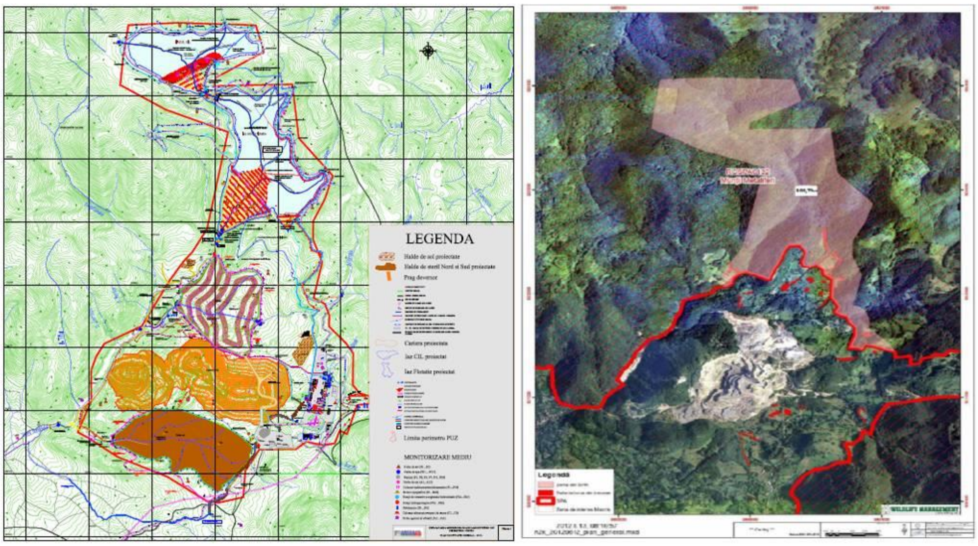

Fig. 1. Certej mining perimeter and its location in relation with Natura 2000 site (HODOR ET AL., 2013)

In november 2004, an exploration drilling campaign was started, which continued until 2005, estimating the reserves at 31.35 Mt for 2.1g/t Au and 11 g/t Ag (FORWARD ET AL., 2009).

MATERIAL AND METHODES

The project involves continuing and developing the mining activity from Certeju de Sus commune, implying exploitation and development of the existing quarry, extraction of precious metals (gold and silver) from the ore, opening and operating the andesite quarry located on Macrisului Valley for building materials, deposition of waste rock and processing slurry, construction of dams for the two tailing ponds, construction of the oxygen and processing plants, construction of the explosives deposit and other objectives for the economic development of the area (access roads, utility networks, environmental protection etc.).

In table 1 are shown the areas of land to be occupied by the project (HODOR ET AL., 2013).

Table 1.

Surfaces of land and types of uses

No.	Location	Surface (ha)
MAIN INDUSTRIAL AREA		
1.	Certej quarry	62.8
2.	North waste dump	32.6
3.	South waste dump	40.2
4.	Processing plant	20.9
5.	Access roads	6.9
6.	Administrative buildings	0.2

7.	Topsoil deposits	7.7
8.	Protection zone (green areas)	65.3
TOTAL MAIN INDUSTRIAL AREA		**236.8**
SECONDARY INDUSTRIAL AREA		
9.	Flotation and cyanidation tailings ponds	63.6
TOTAL INDUSTRIAL AREA		**300.5**
10.	Perimeter protection zone	155.7
TOTAL AREA		**456.2**

Forecast production of processed ore is approx. 3,000,000 t/year, gold concentrate being of approximately 315,000 t/year (RSG, 2007; ALEXANDRER ET AL., 2014).

For processing the quantities of ore and for obtaining the gold concentrate there are needed a range of other raw materials, hazardous or non-hazardous, whose stock and degree of dangerousness are shown in Table 1.

Table 2.

Raw materials required

Name of raw materials or substances	**Annual quantity in stock**	**Classification of raw materials or substances**	
		Hazardous/ Nonhazardous (H/NH)	**Dangerousness**
Ammonium nitrate	3697 tone/year,	NH	-
Initiating explosive - dynamite	229 tone/year, stock 10 t	H	Explosive
Amyl xanthate	390 tone/year; stock 20 t	NH	-
Dowfroth foam	150 tone/year; stock 5 t	NH	-
Aero 3477 - collector	120 tone/year; stock 10 t	NH	-
Copper Sulfate	955 tone/year; stock 25 t	H	Toxic, irritant, dangerous for environment
Sodium Silicate 40%	4,120 tone/year; stock 160 t	NH	-
Hydratate lime (including whitewash)	7,791 tone/year; stock 219.5 t	H	Irritant
Limestone	241605 tone/year; stock 250 t	NH	-
Sodium cyanide (solid and solution)	1653 tone/year ; stock 276 t	H	Toxic, dangerous for environment
Active coal	35 tone/year; stock 55 t	NH	-
Hydrochloric acid	898 tone/year; stock 87 t	H	Corrosive
Sodium hydroxide	328 tone/year; stock 27 t	H	Corrosive
Sodium metabisulphite	1909 tone/year; stock 159 t	H	Toxic, irritant
Flocculent	171 tone/year; stock 28 t	NH	-
Peroxide (50%)	12 tone/year; stock 1 t	H	Oxidizer, Corrosive
Oxygen	183,901 tone/year; stock 154 t	H	Oxidizer
Diesel fuel	5,400,000 l/an; stock 153 mc	H	Inflammable
Oils (engine oil, hydraulic oil)/lubricant	63,000 l/year	H	Irritant, toxic, dangerous for environment
LPG	240 tone/year; stock 10 t	H	Inflammable
Borax	0.607 tone/year	NH	-

Corresponding works to the project objectives will be achieved in four stages: construction, operation, closure and post-closure.

The topsoil deposit derived from the quarry will be located in the vicinity of the preparation plant and the soil from the ponds site will be deposited downstream of the flotation tailings pond. Soil deposition and the construction of the deposits will be conform to conventional technology as to ensure their stability, with steps, and slopes that respect the natural angle.

The volume of soil to be removed taking into account that its thickness varies according to the location is estimated at approx. 1.408.000 m^3 (ALEXANDRER ET AL., 2014).

Mining technology is the usual one for such deposits, respectively drilling-blasting technology. The displaced material will be loaded with backhoe loaders and front loaders to large capacity dumper trucks and the ore is transported to the gyratory crusher. Crushed material (primary crushing) is then transported to the processing plant.

Development of Certej quarry will be carried out progressively, in 4 phases, for high efficiency (figure 2).

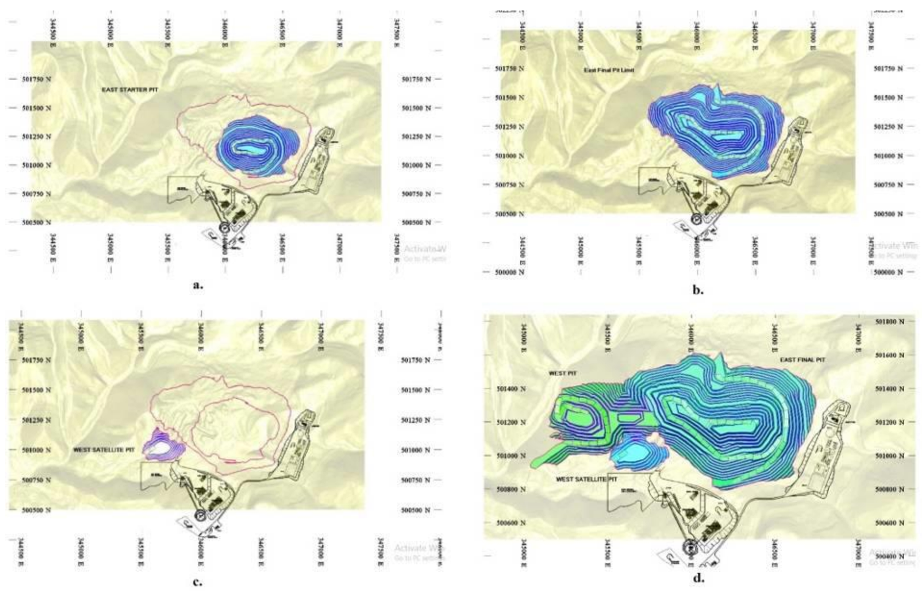

Fig. 2. a. Phase I, opening - East starter pit; b. Phase II – East expansion; c. Phase III – West satellite pit; d. Phase IV – Final quarry (ALEXANDRER ET AL., 2014)

Waste rocks, resulted from the removal of the overburden and quarry's steps profiling works will be stored in two dumps: North and South waste dumps. The material will be transported and deposited using dumper trucks.

Areas with slopes exceeding 10º will be arranged with proper twinning steps in order to create a solid bound between the natural terrain and the waste rocks. Twinning steps are executed with reverse tilt to the foundation.

The North and South waste dumps will be protected by supporting walls on a total length of 600 m, respectively 100 m. They will be executed in 5 m in sections, with compaction grout between them. The foundation of the walls will be made in the bedrock. The crowning of the walls will be executed in steps of 0.5 m following the natural slope of the land. Foundations will be made of concrete (ALEXANDRER ET AL., 2014).

Ore processing will be processed by two well-known methods: flotation and cyanidation. The process for preparing the gold concentrate by flotation involves the use of reactive that is more toxic than cyanide. Cyanidation tailings contains a quantity of cyanide that is considerate harmless to humans and whose concentration will decrease naturally, cyanide decomposing under the effect of light and air into harmless compounds.

Tailings ponds dams will be constructed of rocks (from the andesite quarry), in stages: initiation dam (starter) and successive elevations, their maximum height being 169 m for the flotation tailings pond and 70 m for cyanidation tailings pond.

Upstream slopes of the two dams are protected by three filtering layers, namely: 1.5 m filter made of crushed stone, 1.5 m filter made of fine gravel and sand, and over the fine filter a geotextile and a HDPE geomembrane for waterproofing (HODOR ET AL., 2013).

Tailings ponds will be provided with safety dams located downstream, which will gather the exfiltration.

These two dams will ensure decontamination and disposal of seepage waters to a storage tank. From the storage tank the water is pumped back into the pond, then will be brought inside the processing plant and recycled. Excess water from the flotation tailings pond will be treated and discharged into the natural water courses; clarified water from cyanidation tailings pond is entirely recycled except for extraordinary weather events when these waters will be treated in the Detox II station (FORWARD ET AL., 2009; ALEXANDRER ET AL., 2014).

RESULTS AND DISCUTIONS

Certej mining perimeter is located in a severely degraded area as a result of multiple interactions, on very long-term, between environmental components and anthropogenic factors.

Current state of the environment

Regarding the environment, the area is affected by previous mining activities and has a low value due to historical pollution: polluted water resources, fragmented habitats, degraded landscape, etc.

Water quality - is primarily affected by the uncontrolled discharge of wastewater resulting from the exploitation activities and minerals processing operations, acid waters with high content of pollutants, such as: copper, iron, manganese, arsenic, cadmium, nickel, lead, mercury, selenium, chromium, sulfur, dissolved salts, etc. Currently, mining activities have been abandoned since 2006, the main factor that influences and affects water quality, is the type of mineralization in the area.

Consequently, the exposure of sulphide ores to atmospheric oxygen and water, generates acid mine waters, which are collected through underground galleries and discharged untreated through various mine holes or directly into surface waters as runoff from waste dumps or other uncovered surfaces.

Air quality - around Certej mining area is influenced by sources located both within the industrial site and outside it and are represented by stripped areas of quarries that were exploited till 2006 and associated waste dumps, tailings ponds, surfaces exposed to wind erosion, that have become sources of air pollution with dust particles and, not least, the traffic.

Soil quality – around the mine site presents different forms of degradation such as: surface and deep erosion, landslides, excess moisture from rainfall and lateral leaks. Soils are polluted with heavy metals (Cd, Co, Cr, Cu, Mn, Ni, Pb, Zn), with punctual manifestations, their concentrations do not exceed the limits, and the pH indicates an acidic or moderately acidic reaction.

Flora and fauna - is considered one of the areas with the greatest impact on biodiversity in Romania. The mining activities from the past have led to total elimination of the open natural ecosystems. In areas where human impact has stopped for at least 50-60 years, spontaneous vegetation is present in various stages of development.

Noise and vibrations - because the extraction and processing operations are ceased, the associated noise and vibrations is absent. Currently, the main source of noise in the area is the traffic.

Socioeconomic, situation and human health - mining was the main source of employment, but with its cessation the number of jobs in the area was reduced. The agriculture and tourism are practiced at small-scale, a few months per year, but they are poorly developed.

The population is aging and there is a trend of depopulation of the village. The population shows a significant level of poverty. From a health perspective it is noted that the population has a higher incidence of chronic and acute diseases than the population in other places, one of the causes being represented by public exposure to polluted waters due to the fact that only a part of the locals have access to potable water from the public network.

Identification and assessment of the environmental impact of Certej mining project

Environmental Impact Assessment (EIA) - procedure of identifying and forecasting the impact on the biotic and physical environment and human health, arising from legislative activity, policy, programs, projects and operative procedures, interpretation and communication of information regarding the impacts, but also to highlight measures to prevent, eliminate or reduce to a minimum negative impacts on the environment before they manifest (G.D. NO. 445, 2009).

Environmental impact assessment generated by any anthropogenic project is an essential step, that requires numerous analyzes, studies and researches, which should be covered regardless of the size of the project (ORDER NO. 19, 2010).

Checklist method - checklists are aimed at identifying and assessing the impacts of the analyzed project on environmental components by highlighting the potentially significant effects on them (LAZĂR AND FAUR, 2011).

The results for Certej mining project are synthetically presented in the form of a checklist, which identifies of positive and negative impacts and evaluates the cumulative environmental impact (table 3).

Table 3

Checklist for identification of cumulative impact

Environmental components	Identification of potential negative impacts	Identification of potential positive impacts	Assessing the cumulative impact
Air	air pollution	implementation of specific management plans	negative-insignificant
Water	discharge of treated wastewater, pluvial waters	acid water treatment implementation of specific management plans	neutral
Soil	soil occupation and degradation	implementation of specific management plans	negative-significant
Flora and fauna	habitat changes and losses	establishment of compensatory	neutral

		ecological networks; ecological reconstruction of area; implementation of specific management plans	
Landscape	changing landscape	recovery and rehabilitation of the land; implementation of specific management plans	negative
Noise and vibrations	relatively high levels of noise and vibrations	implementation of specific management plans	negative-insignificant
Socio-economic component (population, patrimony)	resettlement	improvement of living standards; implementation of specific management plans	positive significant

According to the checklist, the cumulative impact of mining project on the environment can be considered negative-negative insignificant. The environmental component „soil" is the most affected, suffering a significant negative impact on long-term while the „socioeconomic" component is characterized by a significant positive impact.

Impact networks method - an impact network allows the identification of direct and indirect impacts chains, primary and secondary, resulting from an action or allows determining the actions that generate a certain impact (LAZĂR AND DUMITRESCU, 2006; LAZĂR AND FAUR, 2011).

In figures 3 and 4 are presented networks built to highlight the impact of primary and secondary impacts of mining activities in Certej area (if the project is implemented), both for quarrying and for gold-silver ore preparation.

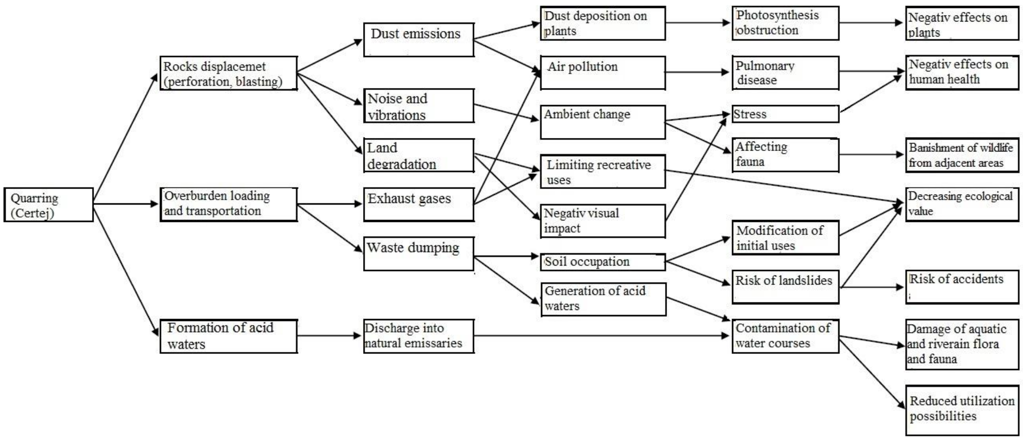

Fig. 3. Impact network for exploitation activities in Certej quarry

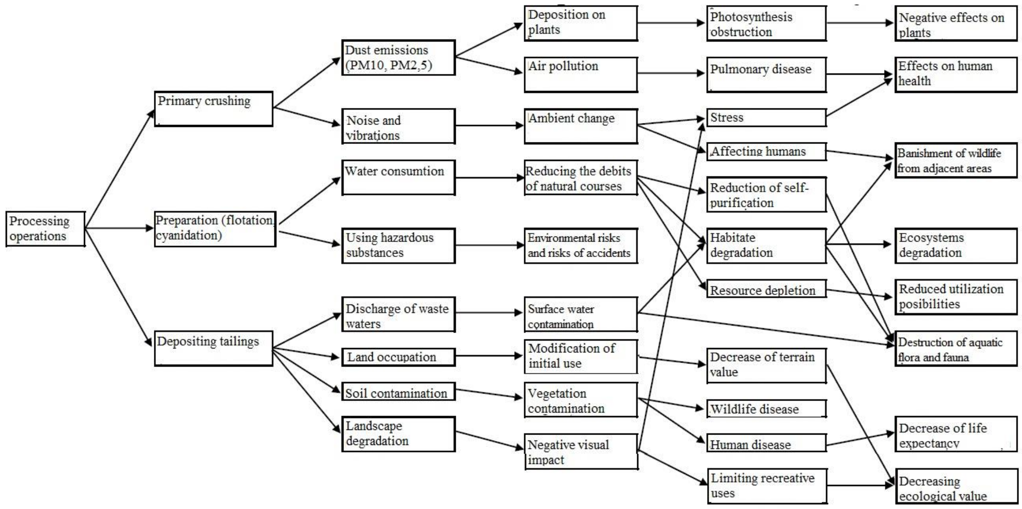

Fig. 4. Impact network for gold-silver ore processing

The impact networks realized for quarrying and processing activities, emphasizes the direct and indirect environmental impacts that could be generated in case of project implementation.

Impact matrices method - matrices consist of double entry tables, in which on the lines are entered environmental components and factors involved, divided and grouped into categories, and on the columns are entered the elementary actions of the project. Each intersection of the matrix represents a potential impact relationship between the project actions and environmental factors (LAZĂR AND DUMITRESCU, 2006; LAZĂR AND FAUR, 2011).

In this paper work it is used a matrix system which follows a logical path of analysis that leads to a summarized scheme, similar to the method of coaxial matrixes, in which the elements generating impact (causal factors) are connected to environmental components, and further to the areal typology in which the objective of the study is placed, highlighting potential environmental interactions (LAZĂR AND FAUR, 2013).

There may be assigned various causal factors to each on-site activity. It is possible to build a matrix whose lines is a list of activities or actions considered relevant and the columns a list of possible individual causal factors.

The existence of a relationship between a relevant activity and a causal factor is emphasized by placing in the cell at the intersection of the line representing the project with the column corresponding to the causal factor. This intersection can be marked in different ways according to the relevance of the represented relationship, and it can consider the impact as: major (3), medium (2), minimal or unimportant (1) or absent.

Thus, for quarrying and ore processing activities it can be build the matrix A, which is the association of the relevant actions and causal factors (Table 4).

Table 4

The association between the relevant actions and causal factors (matrix A)

Matrix A	Causal factors									
Activity	**Macropollutants**	**Micropollutants**	**Radioactive emissions**	**Noise emissions**	**Water consumption**	**Discharge of wastewater**	**Surface flooding**	**Soil occupation**	**Soil waterproofing**	**Traffic**
Quarrying	3	1		3		1		3	1	3
Processing activities	3	3		2	3	3		3	2	2

At this point it can be introduced a third dimension of the problem, consisting of environmental components. In fact, it can be individualized a possible causal relationship between the causal factors, already defined, and the various environmental components, reflected also by a matrix B (predefined).

For each project, from matrixes A and B it can be obtain a third matrix, C, which has the same dimensions as matrix B (lines: environmental components, columns: causal factors), but whose cells contain a combination of the probability contained in the corresponding cell from matrix B with the probability contained in the line corresponding to the analyzed project from matrix A.

To define associations between matrixes interactions the following rules shall be respected: 3*3→3; 2*3→3; 2*2→2; 2*1→1; 3*1→2; 1*1→1; absent*absent/1/2/3→absent.

It is possible to define a matrix D, whose columns are types of areas (where the project is located) and lines consist of environmental components. The matrix is completed with the vulnerability (certain, probable, unlikely or absent) customized for different types of areas (columns) and environmental components (lines).

For the objectives analyzed in this study there were chosen two types of areas: mountainous areas for the quarry and natural areas for the processing activities (given that the location of the two tailing ponds overlaps with a protected area).

By combining matrix C and matrix D, a new matrix E is obtained, whose columns and lines are the causal factors and environmental components. The cells of the matrix contain an indication on the probability of existence of an impact on the environment (table 5).

The last line respectively column sums up the values resulting from multiple combinations of matrixes, and depending on the amounts earned in each row and column it can be appreciated which of the environmental components will be most affected and which of the specific actions of the project will generate the most severe impacts (LAZĂR AND FAUR, 2013).

To assess the environmental impact of Certej mining project (quarrying and gold-silver ore processing), the matrix E (shown in table 5) was completed.

Table 5

Environmental impact assessment generated by relevant activities (final matrix)

Matrix E	Causal factors										
Environmental components	**Macropollutants**	**Micropollutants**	**Radioactive emissions**	**Noise emissions**	**Water consumption**	**Discharge of wastewater**	**Surface flooding**	**Soil occupation**	**Soil waterproofing**	**Traffic**	**TOTAL**
Air quality	3 (3)	2 (3)								3 (3)	8 (9)
Microclimate	2 (3)								2 (3)		4 (6)
Surface waters	3 (3)	2 (3)			(3)	3 (3)			3 (3)		11 (15)
Groundwaters					(3)	3 (3)			3 (3)		6 (9)
Fauna	3 (3)	3 (3)		3 (3)	(3)	3 (3)		3 (3)		3 (3)	18 (21)
Flora	3 (3)	3 (3)			(3)	2 (3)		3 (3)			11 (15)
Ecosystems	3 (3)	2 (3)		3 (3)	(3)	2 (3)		3 (3)	2 (3)	3 (3)	18 (24)
Soil						2 (3)		3 (3)	3 (3)		8 (9)
Lithosphere					(3)						(3)
Noise level				3 (3)						3 (3)	6 (6)
Radiations											
Landscape	3 (3)				(3)	2 (3)		3 (3)	2 (3)	3 (3)	13 (18)
Risk						1 (3)				3 (3)	4 (6)
Mobility										3 (3)	3 (3)
Resources availability				3 (3)	(3)				1 (2)		4 (8)
TOTAL	20 (21)	12 (15)		12 (12)	(24)	18 (24)		15 (15)	16 (20)	21 (21)	**114 (152)**

* Values without brackets are for quarrying (in mountainous areas) and values in the brackets are for processing operations (in natural areas)

Analyzing the final matrix is noted that the processing of ore and tailings deposition in ponds has a potentially and significantly greater impact on the environment than the quarrying activity.

CONCLUSIONS

Certej mining project aims to continue the exploitation and processing of Certej gold-silver ore deposit, activity that started in XVIIth century and that was abandoned in the first decade of the XXIst century, this paper representing a study that aims to identify and assess the environmental impacts of the project.

There were considerate the main stages of mining activity, starting from topsoil recovery, construction and development of tailing ponds, exploitation activity, waste material deposition, processing operations and sterile sludge decantation.

The accent is concentrated on the environmental impacts of mining and processing stages of the project (if implemented), being used three methods, namely: checklists, impact matrices and impact networks.

The last two methods emphasize particularly the negative impacts, while checklist identifies cumulative impacts and interactions between the effects on human and natural environment, showing that project implementation can bring a number of improvements of the existing situation.

According to the impact matrix the entire mining activity from Certej will generate a major negative impact, primarily on the following environmental components: wildlife, ecosystems and landscape. Among the specific quarrying activities, the emissions of macropollutants and traffic will generate the most significant impacts, while the processing activities have as environmental disruption causes the water consumption and discharge of wastewater.

The results obtained for Certej mining project are interpretable, however, given that current technology allows the exploitation and recovery of the gold-silver ore deposit while ensuring environmental protection, imposing the recovery and rehabilitation of affected areas through the implementation and compliance with specific management plans for each environmental components it can be appreciated that the implementation of Certej mining project could bring major benefits on long term, for the local community and environment.

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