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RESEARCH ON THE QUALITY OF THE SOIL AND THE LAND RELATED TO THE MINING PERIMETERS IN VALEA JIULUI

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Abstract: *In the paper, special attention is paid to the sources that lead to soil and land degradation in Valea Jiului, as these are the components of the environment that are most affected by mining activities. Three sources of pollution are analyzed: dumps, mine yards and constructions, and mining and preparation activities chemically polluting of soil. Among the environmental changes, land degradation currently has the most important consequences for human settlements and economic activities, especially through induced subsidence processes and the presence of dumps with reduced stability. The authors of the article propose their own method for establishing a Global Land Degradation Index (GLDI) affected by mining activities in a mining perimeter (mine) taking into account the entire analyzed area (in our case Valea Jiului) and make a classification (in three classes) of this index.*
Keywords: *soil and land degradation, global land degradation index*

1. Introduction

In a region, such as Valea Jiului, where the coal mining and preparation activity has been carried out for an appreciable period of time, special attention must also be paid to the sources that lead to soil and land degradation in that region, because these are the components of the environment that are most affected by mining activities.

In the following, an analysis will be made of the following sources of pollution:

- dumps;
- mine yards and constructions;
- mining and preparation activities that pollute the soil chemically.

2. Dumps

The underground mining activity has unwanted repercussions on the land surface by the fact that it involves the storage of relatively large amounts of mine tailings that contribute to changes in the morphology of the land, land uses and lead to the appearance of new forms of relief. Although compared to the area corresponding to the economic area of Valea Jiului (103,200ha), mining dumps, preparations, slag deposits and abandoned quarries occupy relatively small areas (402.02ha, 0.39%) the contrast between waste rock deposits (clays, marls, sandstones) and the surrounding areas, covered by forests, is an obvious one.

The economic units (predominantly the mining ones), which affected the land in Valea Jiului to the greatest extent (mines and preparations, the Paroșeni thermal power plant, forestry and household activities) and which generated/generate degraded lands of various types, are reproduced in table 1 [1,2].

Mining dumps in Valea Jiului are usually located on slopes or along valleys, with or without drainage. The elevations of the storage lands generally vary between 650m in the axis of the valleys and 750m on the slopes. The angle of inclination of the slopes varies between 6^0 and 35^0. In some situations, the dumps were built in such a way that they block valleys without permanent water courses, forming lakes from waters originating from precipitation (fig.1).

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The presence of these lakes is extremely unfavorable from the point of view of the stability of the dumps. The water that seeps into the dump can cause landslides or plastic or muddy flows (such landslides and muddy flows affecting the colony of Lupeni Municipality) (fig. 2).

Table 1. The economic units that affected the land in Valea Jiului - updated [3]

Economic unit	Name of objective	Area, ha	Surface area of influence, ha	Technical condition	Stability
Dumps resulting from tailings extracted from underground and from the surface					
Lonea mine	Jieț Shaft	5,70	0,40	Activate	Relatively stable
	Lonea I	14,90	0,38	Conservative	Stable
	Defor Valley	2,00	0,40	Conservative	Relatively stable
	Defor open pit	12,65	1,05	Conservative	Relatively stable
	Valley of Ciort	7,19	1,11	Conservative	Relatively stable
	Valley Arsului	2,10	2,50	Conservative	Stable
Petrila mine	2 East	2,10	0,30	Rehabilitated	Stable
South Petrila mine	Jieț West open pit	14,75	1,50	Rehabilitated	Stable
	Shaft 4	3,12	0,20	Rehabilitated	Stable
	Auxiliary Shaft 2, 3	2,50	0,20	Rehabilitated	Stable
Dâlja mine	PA-1	1,74	0,10	Rehabilitated	Stable
	Run	1,74	0,10	Rehabilitated	Stable
	PA-1, PA-2	7,90	4,80	Rehabilitated	Stable
	Refuse heap PA-3	1,20	0,20	Rehabilitated	Stable
Livezeni mine	Auxiliary Shaft East	1,55	0,30	Activate	Relatively stable
	PA-nr.2,3 Maleia	2,15	0,70	Rehabilitated	Relatively stable
Aninoasa mine	Refuse heap Piscu	2,50	3,42	Rehabilitated	Relatively stable
	South Funicular	2,73	0,34	Rehabilitated	Stable
Vulcan mine	Shaft 7 West (old)	9,10	7,60	Conservative	Relatively stable
	ValleyArsului + P8,10	15,75	1,60	Activate	Relatively stable
	Hypollit	3,10	0,30	Conservative	Relatively stable
	Shaft7West	6,30	0,80	Conservative	Relatively stable
Paroșeni mine	Valley Lupului	2,80	0,50	Conservative	Relatively stable
	Funicular	1,17	0,40	Conservative	Relatively stable
	Refuse heap	1,37	-	Conservative	Relatively stable
Lupeni mine	2 West Ileana	14,26	0,04	Activate	Relatively stable
	New branch Ileana	4,61	2,12	Rehabilitated	Relatively stable
	Victoria open pit	2,48	0,02	Conservative	Stable
	New Victoria	6,69	2,62	Conservative	Stable
Bărbăteni mine	Mierleaşu	4,70	0,30	Rehabilitated	Stable
	Adit	0,20	-	Rehabilitated	Stable
Uricani mine	Old Funicular	11,00	3,00	Conservation	Stable
	Balomir	2,18	0,60	Conservation	Stable
	Shaft7Sterminos	3,12	0,60	Conservation	Relatively stable
	New Funicular	2,00	3,00	Conservation	Relatively stable
Valea de Brazi mine	Funicular	0,15	0,30	Rehabilitated	Stable
	Shaft 8	0,04	0,01	Rehabilitated	Stable
Câmpu lui Neag mine	Poiana Mare	9,60	-	Rehabilitated	Stable
	Galbena	1,10	-	Rehabilitated	Stable
	Șesul Șerbanilor	8,60	-	Rehabilitated	Stable
	Frasin	6,80	-	Rehabilitated	Stable
Sum		**207,84 (45,17%)**	**42,11**		
Dumps from coal preparation plants					
Preparation plants	Petrila	25,50	4,00	Conservation	Relatively stable
	Livezeni	2,50	0,70	Activate	Stable
	Coroiești	16,50	-	Activate	Relatively stable
	Lupeni	22,10	2,00	Conservation	Relatively stable
	Uricani	0,10	-	Conservation	Relatively stable
Total		**66,70 (14,50%)**	**6,70**		

Waste dumps				
Petroșani	1,00	2,00	Activate	Unstable
Petrila	2,00	4,00	Activate	Unstable
Vulcan	1,50	3,00	Activate	Unstable
Lupeni	0,50	2,00	Activate	Unstable
Uricani	2,00	4,00	Activate	Unstable
Aninoasa	0,50	1,00	Activate	Unstable
Sum	**7,50 (1,63%)**	**16,00**		
Pot holes and ravines				
Petroșani forestry	5,00	1,00	Conservation	Unstable
Petrila forestry	7,00	1,50	Conservation	Unstable
Lupeni forestry	9,50	2,00	Conservation	Unstable
Sum	**21,50 (4,67%)**	**4,50**		
Slag and ash deposits from the power plant				
Power plant Paroșeni	20,00	-	Activate	Stable
Sum	**20,00 (4,35%)**	**-**		
Abandoned coal pits				
Cimpa open pit	9,30	0,75	Rehabilitated	Stable
Jieț Defor open pit	12,56	1,05	Rehabilitated	Stable
Jieț Vest open pit	6,41	0,50	Rehabilitated	Stable
Victoria Lupeni open pit	12,50	1,10	Rehabilitated	Stable
Uricani Sud open pit	4,37	0,30	Rehabilitated	Stable
Balomir open pit	5,25	0,60	Rehabilitated	Stable
Vineri open pit	0,87	0,10	Rehabilitated	Stable
Mîrșăveni open pit	2,50	-	Rehabilitated	Stable
Câmpu lui Neag Zona E open pit	16,50	1,00	Rehabilitated	Stable
Câmpu lui Neag Zona A+C open pit	29,40	2,00	Rehabilitated	Stable
Galbena open pit	4,37	0,65	Rehabilitated	Stable
Jiri open pit	2,50	0,10	Rehabilitated	Stable
Buta open pit	0,95	-	Rehabilitated	Stable
Sum	**107,48 (23,36%)**	**8,150**		
Land ruptures and gaps				
Petroșani	5,50	-	Activate	Relatively stable
Petrila	4,30	-	Activate	Relatively stable
Lupeni	15,30	-	Activate	Relatively stable
Aninoasa	4,00	-	Activate	Relatively stable
Sum	**29,10 (6,32%)**	**-**		
Sum total	**460,12**	**77,46**		

a

b

c

Figure 1. Water accumulations in the area of Lupeni dumps (a), Valley Arsului-Lonea (b) and between the branches of the Petrila preparation dump (c) [4,5]

a b

Figure 2. Lupeni (a) and New Uricani Funicular (b) dumps affected by erosion, landslides and uneven settlement [9].

The construction of tailing dumps was carried out with the help of funiculars or car transport (e.g. the Valley Arsului dump), thus ensuring both the transport and storage of tailings in the dump. Deposits were carried out on different alignments, and the discharge points were established according to the configuration of the land in the area of the respective alignment. To increase the storage capacity, the spilled material is generally leveled with the help of bulldozers, forming piling platforms. The platforms have widths at the lower part of 50-150m, and at the upper part of 15-50m. By leveling with the help of bulldozers, compaction is also achieved, which contributes to increasing the stability of waste heaps.

A characteristic of the heaps is the fact that they are executed, as a rule, in one step, their parameters being dependent on the morphology of the land, the heights at which the funicular is mounted and the characteristics of the heaped rocks.

The mentioned aspects have unfavorable repercussions on the stability of the dumps, affecting the lands in the immediate vicinity, in the area of influence. The height of the dumps varies between 3-4m and 30-40m. The slope angle in the situations where plastic leaks have occurred has values of 7^0-8^0, but in general it is 40^0-50^0. During the dumping or pushing of the waste material, a granulometric sorting takes place in the sense that the coarse material is deposited at the base of the pile, also, there is a tendency for the material to settle at angles greater than the final ones. In the case of land with a high slope, the flattening of the slope is more obvious and the material requires more room for expansion.

Dumps are generally stable, and the stability reserve is above unitary. Relatively stable are those that have a small reserve of stability that can be canceled in the event of additional efforts or changes in the physical-mechanical characteristics of the piled rocks or the base ground due to the presence of water.

Since the dumps are formed in a single step, due to the large difference in level the rocks tend to move from the slope, facilitating their breaking at the top where cracks and material displacements occur downstream. Because of the plasticity of the bedrock and the high height of the dump steps, crank of rocks occur in many situations.

Currently (see table 1), *tailing dumps from underground and surface mining (41)* are active 4 (37.26ha-18%), under conservation/rehabilitation 17 (91.51ha-44%), greened 20 (79.07ha-38%), are stable 23 (115.13ha-55%) and relatively stable 18 (92.71ha-45%).

Tailings from coal preparations (5) are active 2 (19ha-28%), in conservation/rehabilitation 3 (47.7ha-72%), is stable 1 (2.50ha-4%), with stability relative 4 (64.2ha-96%).

The slag and ash deposits from the Paroşeni thermal power plant (the settling ponds) are in operation. The neighboring lands are not influenced at the moment, but the breaking of the dykes would have disastrous repercussions on them, the possibly affected surfaces being appreciable and difficult to estimate (fig.3).

Figure 3. The settling pond of the Paroşeni thermal power plant [5]

The coal open pits (micro-open pits) in Valea Jiului, in most of them, have been freed from mining duties and tailings or household waste deposits have been created. All these warehouses have been closed and greened. The former Câmpu lui Neag open pit was filled with water, being currently used for recreation and sport fishing (fig. 4).

Figure 4. Former open pit Câmpu lui Neag [4]

The waste dumps are in operation, consisting of household waste (textile materials, paper, glass, wood scraps, metal, plastic materials, food scraps, ash, rubber, etc.), special waste from hospitals (cotton wool, diapers, dressings, paper, organic waste, plastics, etc.) and animal waste (animal carcasses, animal waste). All these deposits show a marked instability (fig. 5).

Figure 5. Petrila waste dump [5]

The pot holes and ravines, resulting from the location of some roads for the close removal of the woody mass, on the slope, represent approx. 5% (26ha, including potentially affected adjacent areas) of the total area of occupied and denatured land in Valea Jiului (fig. 6).

Figure 6. Forest exploitation in the Jieț valley [14]

Due to the relief of Valea Jiului, most of the time the forest exploitations are located in areas with very rugged terrain where the design and location of the access roads require special caution.

The construction of some roads on the slope, very close to the line of the greatest slope, on friable substrate, constituted the premise for triggering the phenomena of deep rain erosion, which had the consequence of the formation of large gullies and ravines. These formations present very steep slopes (40°-60°) deep into the bedrock which in turn contribute to the formation of torrents during periods of heavy rainfall.

Another consequence of the exploitation of the woody mass, especially if the replanting works are delayed, is that of triggering landslides (fig. 7), which, unfortunately, have not been quantified, and their assessment is difficult because they are located in hilly and mountainous areas. This danger should not be neglected even if such phenomena currently affect negligible areas of land in Valea Jiului.

Figure 7. Landslides in the forest exploitation area [4]

Land ruptures and gaps are in a slow evolution affecting the original uses of land and constructions in the exposed areas and represent 7% (29.1ha) of the affected land surface.

Relatively stable and unstable formations will require mine development interventions to bring them to a stable state in order to reintroduce these lands into the economic circuit and landscape reintegration.

Table 2 shows the current and initial uses of land in this category of sources of land damage in Valea Jiului.

Table 2. Affected surfaces and changes of uses [1]

Current uses		**Initial uses, ha**			
Name	**Area, ha**	**Forest**	**Arable**	**Meadow**	**Pasture**
Dumps extracted from underground, surface and coal preparation plants	274,54	15,00	0,50	140,54	118,50
Slag and ash deposits from the power plant (the settling ponds)	20,00	-	2,00	3,00	15,00
Abandoned coal pits	94,18	10,00	0.50	72,30	11,38
Waste dumps	7,50	-	-	4,50	3,00
Pot holes and ravines	21,50	21,50	-	-	-
Land ruptures and gaps	29,10	-	1,50	19,20	8,40
Sum	**446,82**	**46,50**	**4,50**	**239,54**	**156,28**

3. Mine yards and constructions

Depending on the necessary arrangements, the opening method, the technological flow from the surface and the relief of the land, the surface of these mine yards (fig.8) [9] can occupy from several hectares to several tens of hectares (table 3) [6].

Figure 8. The mine yard (abandoned) of Lupeni preparation plant (Shaft with skip in the background) [4]

Table 3. Areas occupied by mining premises and constructions

No. crt.	Mining entity	Used surface, m²	
		Mine yard	Constructions
1.	Lonea mine	999.651	559.217
2.	Petrila mine	283.758	76.129
3.	South Petrila mine	754.196	59.946
4.	Dâlja mine	276.383	129.003
5.	Livezeni mine	421.550	116.115
6.	Aninoasa mine	409.772	166.308
7.	Paroșeni mine	456.591	68.416
8.	Vulcan mine	558.398	218.003
9.	Lupeni mine	1.114.726	713.628
10.	Bărbăteni mine	311.305	96.174
11.	Uricani mine	410.290	149.934
12.	Valea de Brazi mine	165.326	36.974
13.	Câmpu lui Neag mine	120.516	52.684
14.	Petrila preparation plant	1.125.757	546.483
15.	Livezeni preparation plant	320.592	65.138,20
16.	Coroiești preparation plant	976.908	855.603
17.	Lupeni preparation plant	788.335,62	557.374,83
18.	Uricani preparation plant	400.267,95	146.867,70
Sum		**9.336.880,57**	**4.614.000,73**
Sum total		**13.950.881,30m² = 1395ha; 1,35% from the surface of Valea Jiului**	

Other areas of land occupied by access roads, assembly platforms, warehouses, etc. it is estimated at approximately 79 ha.

The general economic regression in Valea Jiului also led to a decrease in the population so that apart from the abandoned mining premises, important areas of land are occupied by other abandoned industrial premises (e.g. the GEROM premises, UPSRUEM, buildings belonging to the former Vâscoza enterprise from Lupeni etc.) as well as abandoned residential buildings (in all cities of Valea Jiului). Although there is no strict record of these lands, an approximation of their surface between 15 and 20ha can be made.

An estimated calculation regarding the land surfaces in Valea Jiului that are/were occupied by anthropogenic activities directly or indirectly related to mining in this area shows that around 1900ha (1.84% of Valea Jiului surface) were affected by these activities, surface which, at a first estimate, would not be relevant, but as has been shown, the objectives, mostly inactive, on these lands leave a landscape and visual aspect much more significant than their extent.

4. Mining and preparation activities that pollute the soil chemically

The soil of Valea Jiului is siliceous, with a low content of iodine and fluorine, poor in humus and therefore unfavorable for the growth of cultivated plants. These aspects have as a consequence the orientation of the population in the area towards herding and implicitly the risk of soil and stream contamination through animal droppings or their improper storage.

The chemical composition of the soil includes all the known elements, although they differ from one region to another, the deficiencies or excess of mineral elements being reflected in the geographic pathology of the population.

In table 4, the percentage distribution of the mineral elements in the soil on the surface of some dumps and in the one that constituted their foundation before deposition (vegetable soil) is given.

Table 4. Percentage distribution of mineral elements in the soil [7]

No. crt.	The mineral element in the soil	MU	Determined value				
			Parosẹni	Vulcan	Lupeni	Uricani	Vegetable soil
1.	SiO_2	%	61,87	64,92	67,11	65,23	64,23
2.	Al_2O_3		11,22	11,81	11,86	10,98	9,81
3.	Fe_2O_3		3,60	3,63	3,28	3,21	3,45
4.	MgO		0,93	0,92	0,90	0,78	0,71
5.	CaO		0,87	0,84	0,87	0,76	0,77
6.	Na_2O		0,99	1,05	1,11	0,91	1,07
7.	K_2O		1,58	1,63	1,70	1,45	1,80
8.	Volatile		18,94	15,20	13,28	16,68	18,16

In addition to the physical degradation processes, in Valea Jiului there are also processes of chemical degradation of the land, through *pollution with heavy metals* (in the areas occupied by tailings deposits and in the mining premises), with *sedimentable powders* transported from the dumps or *other pollutants* (e.g. SO_2). These processes affect soil fertility, recovery being in most cases impossible.

Substances that pollute the soil are organic and inorganic in nature and have negative effects on the biological activity in the soil. The possibility of soil pollution with harmful substances resulting from the mining activity is primarily related to the presence of such substances in the material stored in the dumps, which then reach the neighboring lands through precipitation.

The following will present the results of the laboratory analyses, carried out in the chemistry laboratories of the University of Petroșani and the environmental laboratory of CNH Petroșani (with the S4 Pioneer Spectrometer), of the soil samples collected both from the mining premises and the surrounding areas, as well as from tailings dumps for several years (2010-2020).

It should be noted that most of the data presented here were taken from works developed during this period [8, 9, 10], with the aim of obtaining a more accurate picture of the situation regarding the quality of the soil, from a chemical point of view, in Valea Jiului (table 5).

Table 5. Soil chemical analyzes in the mining perimeters in Valea Jiului (multiannual average values)

No. crt.	Parameter	MU	Value determined in the mining perimeter							MAC Cf. Order no. 756/1997
			Lonea	Livezeni	Parosẹni	Vulcan	Lupeni	Uricani	Vegetable soil	
1.	pH	unit. pH	7,09	7,13	7,06	7,13	7,12	6,98	7,56	6,5-8,5
2.	Arsenic (As)	mg/kg d.s.	5	4	4	4	3	3	2	5
3.	Barium (Ba)		501	349	322	349	322	241	343	200
4.	Cobalt (Co)		13	5	5	5	5	4	6	15
5.	Chromium (Cr^{+3})		186	126	112	126	127	123	125	30
6.	Copper (Cu)		5	2	0	2	0	1	1,9	20
7.	Fluor (F)		78	93	94	90	62	76	78	150
8.	Manganese (Mn)		330	310	307	310	294	288	305	900
9.	Nickel (Ni)		18	16	17	16	16	14	15	20
10.	Lead (Pb)		20	21	21	21	20	19	23	20
11.	Sulphur (S)		347	338	327	360	343	342	310	400
12.	Tin (Sn)		9	8	9	10	8	7	7	20
13.	Vanadium (V)		102	101	101	101	104	98	121	50
14.	Zinc (Zn)		63	47	46	47	45	44	43	100

From table 5, it can be seen that there are no exceedances of the concentrations of chemical elements (except barium, chromium and vanadium) compared to those established within the norms for less sensitive uses.

The presence of certain elements, both in the composition of the soil and in that of the waste heaps in concentrations close in value, leads to the conclusion that there is no contamination of the soil caused by the chemical composition of the waste materials stored in the heaps.

Although not directly related to mining activities, it should be remembered that there are also small areas of land polluted with petroleum products (in the vicinity of fuel depots) and transformer oils (in the vicinity of transformer stations).

5. Assessment of soil/land degradation

In Valea Jiului, soil/land pollution has multiple causes, but mining and indirect activities related to it have a significant weight.

The negative effects exerted by mining (mainly) on the soils/land in Valea Jiului are highlighted by: *changes in the relief*, manifested by the degradation of the landscape and displacement of households and industrial facilities from the mining areas; *the occupation of some areas of land* for the activity of mining, piling, coal storage, access roads etc., areas that thus become totally unusable for other purposes, for a long period of time, with effects on local communities; *land degradation*, through vertical and horizontal movements of the surface (induced subsidence) and the sliding of dumps and settling ponds, causing serious accidents and *chemical soil pollution*, which can affect its fertile properties for many years.

The land surfaces in Valea Jiului that are/were occupied by human activities, directly or indirectly related to mining in this area, are valued at approx. 1900ha, which represents 1.84% of the surface of Valea Jiului, an area which, at first estimate, would not be relevant, but as it was shown, the objectives, mostly inactive, on these lands leave a much better landscape and visual aspect significantly than their extent.

Among the different categories of soil pollution (organic, chemical and biological), the chemical one can be attributed the biggest blame (approx. 50%).

Special attention must be paid to the role of mining activities in environmental degradation through the placement of tailings, the existence of abandoned quarries and tailing ponds, and subsidence induced by underground workings.

The extent of land degradation processes through mining activities can be appreciated through a series of indicators such as: the surface occupied by quarries, tailings dumps and settling ponds, the surface affected by induced subsidence, the surface affected by soil, groundwater and vegetation pollution, the surface of land rehabilitated through greening actions or the surface of naturally grassed land.

For a quantitative assessment of the negative effects induced by mining on land, in the specialized literature there are a series of assessments of the degree of land degradation by mining activities. The work of Andrei Costache [4] is noteworthy, which proposes the determination of the Land Degradation Index through mining activities ($I_{d.min}$) by calculating some degradation indices for each objective (dump, quarry, dump instability).

We propose a proprietary method for establishing a Global Land Degradation Index (GLDI) affected by mining activities in a mining perimeter (mine) taking into account the entire analyzed area (in our case Valea Jiului) [3].

This is a global index because it includes several partial indices determined for each individual objective (dump, quarry, induced subsidence, area of influence, greened area, etc.), compared because the area of each objective is related to the largest area of analyzed objectives. It is also temporary because it is determined at a given moment, it being different over time with the implementation of measures to improve the technical condition of abandoned dumps and quarries and especially with the expansion of greening works on degraded lands.

The proposed calculation relationship is:

$$GLDI = \sum_{i=1}^{n} I_i - \sum_{j=1}^{m} I_j \quad (1)$$

where: I_i – partial indices corresponding to the objectives that cause land degradation in a mining perimeter (mine): dumps, open pits, subsidence, areas of influence for relatively stable/unstable dumps, mine yards-constructions etc.

I_j - partial indices corresponding to the objectives that are/were reproduced in the economic circuit: the reconstruction of the landscape as it was before the degradation, finding new uses for the land, temporary development of the affected areas etc.

These partial indices take values from 0 (the value of the objective surface is zero) to 1 (the value of the objective surface is the maximum from the string of values of the entire analyzed area) and are calculated with the relation:

$$I_i \text{ or } I_j = \frac{S_{ef}}{S_{max}} \quad (2)$$

where: S_{ef} – the effective area of an objective in a mining perimeter (mine);

S_{max} – the maximum area of the objective from the series of areas of these analyzed objectives in an area.

For Valea Jiului, considering the current concrete situation [11] regarding land degradation by mining and the degree of greening of these lands, it will be considered: n = 5 (dumps, open pits, subsidence, mine yards-constructions and areas of influence) and m = 1 (naturally or anthropically greened lands).

For the calculation of this Index (GLDI), tables 1 and 3 were used, from which the necessary data were extracted, data which were centralized in tables 6 and 7

Table 6. GLDI calculation parameters

Objective name	**The maximum area of an objective in Valea Jiului S_{max}, ha**
Dumps	50,14
Open pits	53,72
Subsidence	15,30
Mine yards and constructions	317,41
Influence zones	40,97
Rehabilitation lands	205,30

Table 7. Land degradation index, GLDI

Economic unit, mine and preparation plant	**Name of objective**	**Effective area of objective, (S_{ef}), ha**	**Partial degradation indices, I_i or I_j**	**Global Land Degradation Index, GLDI**
Lonea	Dumps	44,54	0,89	**1,84**
	Open pits	21,86	0,41	
	Subsidence	-	-	
	Mine yards and constructions	155,90	0,49	
	Influence zones	6,56	0,16	
	Rehabilitation lands	21,86	0,11	
Petrila	Dumps	27,60	0,55	**0,47**
	Open pits	-	-	
	Subsidence	4,30	0,28	
	Mine yards and constructions	203,22	0,64	
	Influence zones	-	-	
	Rehabilitation lands	**205,30**	1,00	
Petrila Sud	Dumps	20,37	0,41	**0,39**
	Open pits	6,41	0,12	
	Subsidence	-	-	
	Mine yards and constructions	25,67	0,08	
	Influence zones	-	-	
	Rehabilitation lands	46,04	0,22	
Dâlja	Dumps	12,58	0,25	**0,48**
	Open pits	-	-	
	Subsidence	5,50	0,36	
	Mine yards and constructions	40,54	0,13	
	Influence zones	-	-	
	Rehabilitation lands	53,12	0,26	
Livezeni	Dumps	6,20	0,12	**0,42**
	Open pits	-	-	
	Subsidence	-	-	
	Mine yards and constructions	92,42	0,29	
	Influence zones	1,00	0,02	
	Rehabilitation lands	2,15	0,01	

Aninoasa	Dumps	5,23	0,10	**0,31**
	Open pits	-	-	
	Subsidence	4,00	0,26	
	Mine yards and constructions	57,62	0,18	
	Influence zones	3,42	0,08	
	Rehabilitation lands	62,85	0,31	
Vulcan	Dumps	34,25	0,68	**1,76**
	Open pits	-	-	
	Subsidence	-	-	
	Mine yards and constructions	77,64	0,24	
	Influence zones	34,25	0,84	
	Rehabilitation lands	-	-	
Paroșeni + Coroiești	Dumps	21,84	0,43	**1,69**
	Open pits	-	-	
	Subsidence	-	-	
	Mine yards and constructions	235,75	0,74	
	Influence zones	21,84	0,53	
	Rehabilitation lands	1,37	0,01	
Lupeni	Dumps	**50,14**	1,00	**3,57**
	Open pits	12,50	0,23	
	Subsidence	**15,30**	1,00	
	Mine yards and constructions	**317,41**	1,00	
	Influence zones	**40,97**	1,00	
	Rehabilitation lands	134,78	0,66	
Bărbăteni	Dumps	4,90	0,10	**0,01**
	Open pits	-	-	
	Subsidence	-	-	
	Mine yards and constructions	40,75	0,13	
	Influence zones	-	-	
	Rehabilitation lands	45,65	0,22	
Uricani	Dumps	18,40	0,37	**0,85**
	Open pits	12,99	0,24	
	Subsidence	-	-	
	Mine yards and constructions	110,75	0,35	
	Influence zones	-	-	
	Rehabilitation lands	21,87	0,11	
Valea de Brazi	Dumps	0,19	0,01	**0,00**
	Open pits	-	-	
	Subsidence	-	-	
	Mine yards and constructions	20,23	0,07	
	Influence zones	-	-	
	Rehabilitation lands	20,42	0,08	
Câmpu lui Neag	Dumps	28,30	0,56	**1,13**
	Open pits	**53,72**	1,00	
	Subsidence	-	-	
	Mine yards and constructions	17,32	0,05	
	Influence zones	-	-	
	Rehabilitation lands	99,34	0,48	

Table 8 presents a quantitative and qualitative classification of the degree of land degradation due to mining activities, which allowed the classification of each mining perimeter (mine) in a certain category of degradation.

Table 8 Classification of land degradation according to the Degradation Index, GLDI

The value of IGDT	The degree of land degradation	Mining perimeter (mine)
$0 \leq IGDT \leq 1,00$	small	Petrila, Petrila Sud, Dâlja, Livezeni, Aninoasa, Bărbăteni, Uricani, Valea de Brazi
$1,01 \leq IGDT \leq 2,00$	medium	Lonea, Vulcan, Paroșeni, Câmpu lui Neag
$IGDT > 2,00$	large	Lupeni

6. Conclusions

In Valea Jiului, soil / land pollution has multiple causes, but mining and indirect activities related to it have a significant weight.

The paper analyzed the negative effects exerted by mining (mainly) on the soils / lands of Valea Jiului through: changes in the relief, manifested by the degradation of the landscape and displacement of households and industrial objects from the exploitation areas; the occupation of some areas of land for the activity of mining, dumping, coal storage, access roads, etc., areas that thus become totally unusable for other purposes, for a long period of time, with effects on local communities; land degradation, through vertical and horizontal movements of the surface and the sliding of dumps and settling ponds, causing serious accidents and chemical pollution of the soil, which can affect its fertile properties for many years.

As shown, the land surfaces in Valea Jiului that are/were occupied by human activities, directly or indirectly related to mining in this area, are valued at approx. 1900ha, which represents 1.84% of the surface of Valea Jiului, an area which, at first estimate, would not be relevant, but as it was shown, the objectives, mostly inactive, on these lands leave a much better landscape and visual aspect significantly than their extent

Among the environmental changes, land degradation currently has the most important consequences for human settlements and economic activities, especially through induced subsidence processes and the presence of tailings deposits with reduced stability. The calculation of the land degradation index caused by mining activities highlighted the fact that the most affected are the mining perimeters in the center and east of Valea Jiului, respectively Vulcan, Lupeni and Lonea, which also extend into the suburbs of Petrila settlements (Lonea colony, Cimpa), Jieț, Vulcan (north), Lupeni (east and north).

In the last 10-12 years, the closure of the majority of mines in Valea Jiului and the upgrading of some major sources of pollution (e.g. the Coroiești preparation plant), have contributed to an important extent to reducing the impact of extractive activities on the environment (e.g. the significant decrease in the concentration of suspensions solids in the waters of the Jiu). However, with the development of alternative economic activities, new sources of imbalance at the local level appeared, namely tourism (through the chaotic expansion of accommodation units in the mountain area, in Straja and in Parâng) and the exploitation and primary processing of wood. These, together with agro-pastoral activities and legislative changes, lead to pollution phenomena (e.g. water pollution with wood waste and animal residues), but also to new changes in land use and vegetation. Thus, the change in the land ownership regime, grazing in the forest, uncontrolled cutting, burning of some land and pastoral pressure on the land have caused changes in the structure and composition of forests and meadows.

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