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URBAN RECOVERY POTENTIAL OF THE AQUATIC ECOSYSTEMS DEVELOPED ON THE DEGRADED LAND BY MINING ACTIVITIES IN THE WEST PART OF PETROSANI DEPRESSION

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Abstract: *Industrial recovery is a very important issue and a useful way to replace the degraded land, industrial objectives and to reuse the abandoned sites. It's important to use a model of including the abandoned industrial territories in the local economic circuit and to integrate these constructions and landforms in the urban network.*
This paper wants to highlight the economic potential of aquatic ecosystems developed on degraded lands, using a rapid method of impact assessment and to show that nature has the ability to recover in a new shape useful for human society.
Keywords: *aquatic ecosystem, coal pit, sterile dump, urban recovery*

1. Introduction

Most often, the long presence of industrial sites in close proximity to the town is fixed in the citizens' memory. The extra-metropolitan industrial areas were more difficult to integrate into the city's landscape. Almost all the time, factories were the basis of the cities' economic development and with the cessation of their operation, the city slowly died. They leave behind empty spaces, holes that digest the areas left behind, until they are gone [1].

The mining industry involves a reciprocal relationship between Mother Nature and mankind as well as between economic development and society development versus ecology. As a result, to extract the useful mineral substance, the mining industry also has the task to solve the problem of removing its negative impacts on the environment. To solve this problem collaboration among specialists from different fields is required: earth sciences, mining, urban planning and human sciences.

Petroşani Depression is administratively divided into six cities, three of which are municipalities (Petroşani, Lupeni and Vulcan). The main activities of the inhabitants of Petroşani Depression were related to mining and the restructuring of the extractive industry in Romania also meant the closure of some mining operations and coal preparation operations in the Jiului Valley (Dâlja, Aninoasa, Petrila, Petrila Sud, Valea de Brazi, Bărbăteni, Uricani, respectively the preparations from Petrila, Livezeni, Lupeni and Uricani), (Figure 1), which in turn led to a reduction in the number of employees in the mining and preparation sectors.

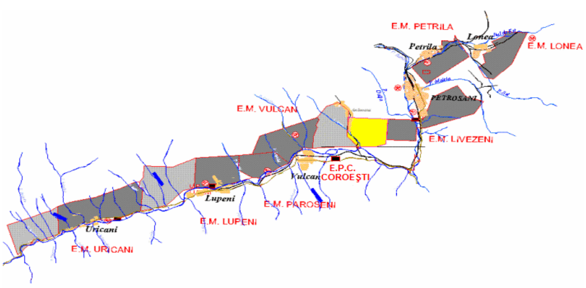

Figure 1. Petroşani mining basin

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The problems caused by the extraction of coal in this area were manifested on water quality (e.g. pollution of Jiu River which had resulted in aquatic fauna disappearance), air quality (e.g. pollution with fine particles resulting from the preparation/storage of coal and sterile resulting from extraction, but also due to its burning at Paroșeni thermal power plant) or soil quality (e.g. pollution due to the tailings dumps), as well as on the health of the population.

2. Analysis of the main aquatic ecosystems

2.1. Mierlașului Valley aquatic ecosystem

Such ecosystems were identified on Mierlaşului Valley (on some maps Mierleasa Valley) where the tailing was dumped from Bărbăteni Mining Exploitation and on Arsului Valley, where the tailing from Vulcan Mining Exploitation was deposited. The dump from Bărbăteni mine is located 2 km north from Lupeni town and about 450 m from the main site. It is located on the left side of Mierlaşu Valley, on the southern slope of the hill.

This dump was formed for the purpose of storing the tailing resulting from the technological processes of digging the mining works from E.M. Bărbăteni. The tailings are stored with the help of the funicular installation. The landfill is located transversely to Mierlaşu Valley, on its left side. The largest amount of tailings has been deposited since 1980. In recent years, nothing has been dumped in the area from the preparation or investment works, the dump being used only for storing the ash resulting from the thermal plant of the mine. The tailings resulting from underground mining works are represented by a heterogeneous mixture, in terms of petrography and granulometry. From a petrographic point of view, the mixture consists of clays, marls, sandstones, coal shales [2].

Atmospheric precipitation has its maximum frequency in April-May and September-October, constituting the source of water supply for the water table and some springs in the area. Landslides led to the partial damming of the stream and the formation of a lake upstream of the dump body at the western end of the dump (Figure 2).

At an altitude of 867 m, the lake has an oval shape, with the banks covered with spruces and birches of different ages. The water has a pH of 7.65, free of biogenic salts, with low concentrations of calcium (24.6 $mg\cdot dm^{-3}$), respectively magnesium (4.4 $mg\cdot dm^{-3}$) and is well oxygenated.

In order to see if the waters from the surface accumulations have any influence on the water table, samples were analysed from a spring located near the lake (figure 3), a spring from which a stream, a tributary of Mierlaş, originates. Physic-chemical parameters indicate water that falls within the norms of drinking water (Table 1), so the water table in Mierlaşului hydrographic basin is not affected by the seepage waters that wash the dump nor by the lake.

Figure 2. The lake from Mierlașului Valley

Figure 3. The place of water sampling from the spring

Table 1. Physic-chemical parameters of the spring water from Valea Mierlaşului

Quality indicator	Value
Conductivity	171 μS
pH	7.40
Metals (Cd, Cr, Pb, Cu, Zn, Mn, Fe, Ni)	0.00 $mg.dm^{-3}$
Calcium	21.5 $mg.dm^{-3}$
Magnesium	2.6 $mg.dm^{-3}$
Phosphor	0.0 $mg.dm^{-3}$
Cyanides, phenols	0.0 $mg.dm^{-3}$
Sulphate	12.3 $mg.dm^{-3}$
Anionic detergents	0.00 $mg.dm^{-3}$
CBO_5	0.6 $mg.dm^{-3}$
CCO-Cr	2.1 $mg.dm^{-3}$

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2.2. The complex of lakes from Lupeni town

The R-3 tailings dump of Lupeni Mine is part of the dump system of the former Lupeni preparation and is currently managed by E.M. Lupeni, being an active dump. It is located in a hilly area between the valley of Ferejele stream and the area of Boncii stream, being made up of two dump bodies, namely the joint body with the R-1 and R-2 branches, from the area of the angular actuation station and the body from the return station located on Renghii Hill [2].

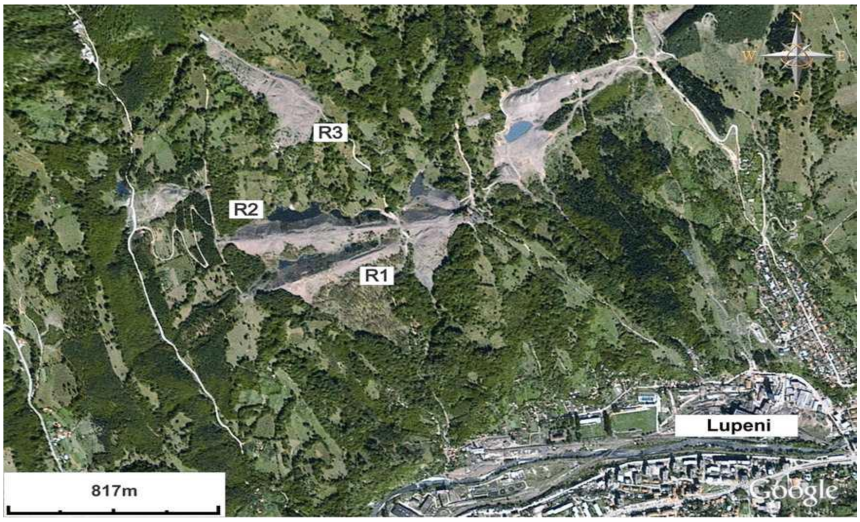

Figure 4. Tailings dumps near Lupeni town
(source: Google Earth, 2023)

The alignment of the R-3 branch is located north of the R-2 branch and forms an angle of 40^{o}, compared to it, with an older lake located between them. Between R-1 and R-2 there is a lake (figure 5). It comes out of alignment, being located at the foot of Renghii Hill, another lake, called by the locals the Green Lake (Figure 6).


Figure 5. The lake from the eastern side


Figure 6. Green Lake

The hills around the area are wooded with beech; among the rather sparse trunks are bushes of hawthorn and rosehip, as well as willow. In some places there are also acacias. The old heaps are reinforced with birch, but the sea buckthorn is expanding, already forming thickets on the slopes of the main heap. On the R-3 dump it was found a fairly extensive area covered with Pteridium aquilinum. Among the herbaceous plants it has been encountered in other areas of the Jiului Valley, Lysimachia numularia and Centaurium erythraea Rafin. Lacerta muraria L was found in the foliage [3].

From the point of view of the physical-chemical parameters, the waters have a relatively high conductivity (between 1000 and 1100 μS), a slightly basic character (pH=7.63) with high values (pH=8.05) in the Green Lake where the seepage waters change the water parameters, on the shore developing a mass of algae (Spyrogyra sp.) with orange deposits. The zinc content varies between 0.01 mg.dm^{-3} and 0.08 mg.dm^{-3}. Waters have a eutrophic character and are well oxygenated. The zooplankton is dominated by micro-crustaceans (cladocerae and cyclopoid copepods, adults and juveniles, proving that a second reproductive spawning was caught, the one at the end of summer) [3].

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3. Methodology used for environmental assessment (RIAM)

The results obtained in the field together with the previous information about this area were used in order to complete an assessment matrix (RIAM - Rapid Impact Assessment Matrix) [4].

This assessment method was designed according to the model offered by Pastakia and Jensen in 1998. It is a useful method to organize, analyse and present the results of the environmental impact assessment. RIAM was originally developed to compare alternatives within a project, but it can be successfully used to compare different plans and programs in terms of their environmental impact [5].

The assessment matrix can be modified according to the different criteria that the evaluator wants to achieve, given that the evaluation scale offered by the author is a variable one. For the studied site, the environmental elements were initially identified, selected from Leopold's matrix (1971) and these were divided into three large classes:
- physical and chemical elements (12 elements);
- biological and ecological elements (10 elements);
- socioeconomic and cultural elements (14 elements).

The elements were analysed based on the evaluation criteria presented in Table 2. The first two evaluation criteria (A1 and A2) can individually change the obtained environmental score, while the next three (B1, B2, B3) cannot change the obtained environmental score. Each evaluation criterion presents a scale that will represent the grade obtained by the environmental element.

Table 2. Evaluation criteria of the anthropogenic impact (after Pastakia, Jensen, 1998)

Evaluation criterion	Description	Grade of assessment
A_1 The importance of the environmental condition / factor	Great for regional area	4
	Great for national area	3
	Great only for town	2
	Great only for site	1
	Without importance	0
A_2 The magnitude of the environmental effect	Great benefit	+ 3
	Significant improvement of the status-quo	+ 2
	Improvement of the status-quo	+1
	No change to the status quo	0
	Negative change in status-quo	- 1
	Disadvantages or significant negative changes	- 2
	Disadvantages or major significant negative changes	- 3
B_1 Permanence	No changes	1
	Provisional	2
	Permanently	3
B_2 Reversibility	No changes	1
	Provisional	2
	Permanently	3
B_3 Cumulativeness	No changes	1
	Unique	2
	Cumulative	3

Unlike the matrix provided by Pastakia and Jensen (1998), it was chosen for evaluation criterion A1 (importance of environmental condition/factor) to modify the evaluation scale by considering the importance of the impact starting from the local level of the site and continuing up to nationally.

Permanence - criterion B_1, it was considered an impact to be permanent when it affects the environmental component for a period longer than 15 years.

Reversibility - criterion B_2, was taken into account in terms of the fact that an impact is reversible when, in a period of 15 years, it can change its importance in relation to the environmental element it affects.

I was considered a cumulative impact when it is also influenced by other factors (e.g.: the handling of machinery on the dump, the level of culture and education of the population, the economic situation, local weather etc.)

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Based on the following ideas, an environmental score (SE) was calculated for each individual element using the formulas:

$$(A1) \times (A2) = (At) \tag{1}$$

$$(B1) + (B2) + (B3) = (Bt) \tag{2}$$

$$(At) \times (Bt) = (SE) \tag{3}$$

According to the score, the result was used into an impact category (table 3). The environmental score and the impact class were calculated both for each element and for the entire area.

The creation of the assessment matrix also took into account the results obtained on the aquatic environments (lakes) in the area. They showed that pH and TDS values were within legal limits.

Table 3. Impact classes based on environmental scores

Environmental score	Impact class	Class description
≥ 101	+ E	Great positive impact
76 - 100	+ D	Important positive impact
51 - 75	+ C	Moderate positive impact
26 - 50	+ B	Positive impact
1 - 25	+ A	Little positive impact
0	N	Without change
- 1 to - 25	- A	Slightly negative impact
- 26 to - 50	- B	Negative impact
- 51 to - 75	- C	Moderate negative impact
- 76 to - 100	- D	Significant negative impact
≤ 101	- E	Major negative impact

Table 4. Impact matrix analysis

Environmental elements	A_1	A_2	B_1	B_2	B_3	SE	CI
Physical and chemical elements							
Quality of water	1	- 1	1	2	3	- 6	- A
Quality of air	1	- 1	2	2	3	- 7	- A
Local climate	1	- 1	3	2	3	- 8	- A
Relief	1	- 2	3	3	2	- 16	- A
Land affected by water	1	- 1	3	3	2	- 8	- A
Affected soil surface	1	- 2	3	2	3	- 16	- A
Quality of soil	1	- 1	3	1	3	- 9	- A
Sedimentation	1	- 1	1	1	1	- 3	- A
Settlement	1	- 1	3	1	3	- 7	- A
Torrential erosion	1	- 1	2	2	3	- 7	- A
Floods	1	- 1	2	2	1	- 5	- A
Areas with landslides	1	- 2	3	2	3	- 16	- A
Environmental score						- 109	- E
Cultural and social-economic elements							
Land use	2	+ 1	3	2	3	+ 16	+ A
Wild spaces	2	+ 1	3	2	2	+ 14	+ A
Wet areas	2	+ 2	3	3	2	+ 32	+ B
Forested land	1	+ 2	3	2	2	+ 14	+ A
Lifestyle	2	+ 1	2	2	3	+ 14	+ A
Landscape quality	2	+ 1	3	2	3	+ 16	+ A
Human health and safety	2	- 1	1	1	1	- 6	- A
Fishing	2	+ 1	3	2	3	+ 16	+ A
Camping	2	+ 1	3	2	3	+ 16	+ A
Unemployment rate	2	+ 1	2	2	1	+ 10	+ A
Leisure	2	+ 1	3	2	3	+ 16	+ A
Waste storage	1	- 1	2	2	3	- 7	- A
Buildings and other constructions	1	0	2	2	1	0	N
Access roads	1	0	2	1	1	0	N
Environmental score						+ 135	+ E

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From this assessment matrix, it is observed that the major impact is manifested on the physical and chemical elements. Their condition is deteriorated as a result of tailings storage and is amplified by the activities generated by the storage process and weather. A part of the impact produced on these elements is reversible under conditions where it can be ameliorated shortly. Although the separately analysed elements show only slightly negative environmental changes, their cumulative impact indicates negative and major environmental changes (Table 4).

The biological and ecological elements indicate little positive changes. That aspect is explained by the development of new aquatic ecosystems that led to the appearance of new plant and animal species in the analysed area. Dump bodies, although they also initially affected the biological and ecological elements, now show a good biological status and an increased capacity to sustain life.

The environmental score obtained after using the impact matrix is + 135, which represents impact class E (major positive impact). If we compare this value with the one obtained 12 years ago by other researchers, namely -56, representing the impact class - C (moderate negative impact), we can say that in almost one decade the nature had the ability to restore itself gradually, offering physical support for leisure and recreation activities. In this way, human society can capitalize on this potential of aquatic ecosystems for tourism purposes.

4. Conclusions

Since mining activity has left a significant mark on Petrosani depression's landscape, there is a need to find specific solutions for aesthetic and economic reintegration. In order for these solutions to be effective, profitable and possible to implement in this area, the physical characteristics of the area, as well as the economic and social ones have to be considered.

The environmental score shows an important environmental change generated by tailing dumps. All the effects of these impacts show the connexion between the environment and citizens and it can be influenced by the educational and cultural level of the community and the local decision makers.

The social and economic elements suffer a general negative impact (in terms of the alteration of the local natural potential) with the mention that the local residents exploit the lands related to the tailings dumps for recreational and leisure purposes. As such, through the activities that population carries out at the level of the site, we can talk about a new approach of land use and a new function, namely the pseudo-tourist one. So it can be taken into account that this area can be capitalized and exploited by the positive impact of recreational activities.

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