Revista Minelor – Mining Revue
ISSN-L 1220-2053 / ISSN 2247-8590
vol. 28, issue 4 / 2022, pp. 24-32

THE INFLUENCE OF THE EXPLOITATION OF MINERAL DEPOSITS AND USEFUL ROCKS ON THE ENVIRONMENTAL COMPONENTS ANALYZED IN SĂLAJ COUNTY

George Ionuț Răzvan FAZACAȘ [1*]

[1] University of Petroșani, Petroșani, Romania, fazacasgir@gmail.com

DOI: 10.2478/minrv-2022-0027

Abstract: *Starting from the importance of the mining industry and how it influences the environment, environmental components and human settlements, this study analysed the activity of Prodănești, Moigrad and Marca quarries, from Sălaj county and how their activity influences the environmental components, air, water and noise. The analysis focuses on the interpretation of the test reports for the years 2016-2019, imposed in the regulatory acts, by the environmental protection authority.*
Keywords: *quarries, AM, water, air, noise, environmental impact, test reports*

1. Introduction

Useful rocks are exploited in numerous quarries and gravel pits spread throughout the territory of the country, having national, regional and local importance [1], within the national economy it is necessary to capitalize on any resource especially the local ones [1].

The mining industry exerts on the environment special influences that manifest themselves in all technological phases and exploitation processes contributing to a great extent to the pollution of the natural receptors in the area [2].

Mainly, the sources of pollution regarding the exploitation of deposits in quarries are the emission of dust, particulate matter and noise that come mainly from the transport of cars and the handling of machinery and mineral aggregates, the detonation of explosives, affecting in particular the activity of personnel but also of nearby vegetation that leads to the diminosis of photosynthesis and implicitly the development of plant biomass [2].

The influence of useful mineral and rock deposits have an impact on environmental components, so it is important "to monitor, forecast, warn and intervene in order to systematically assess the dynamics of the qualitative characteristics of the environmental elements, in order to know their quality status and ecological significance, the evolution and social implications of the changes produced, followed by the necessary measures" [3].

Monitoring can be conducted for various purposes, including establishing environmental "baselines, trends and cumulative effects" [4].

In this study are analysed according to chapter III, the environmental monitoring, from AM [5], [6], [7], physico-chemical, bacteriological and biological indicators emitted, pollutant emissions, the frequency of environmental factors air, water as well as noise from the mining perimeters of Prodăneşti, Moigrad and Marca quarries.

The objects studied in Fig.1 are located partially in the inner city of the localities A) Prodănești locality, B) Moigrad locality, C) Marca locality, having as main activity the extraction of ornamental stone and stone for construction [5], [6], respectively the extraction of stone limestone, gypsum, chalk and slate**.**

[*] Corresponding author: Fazacaș George Ionuț Răzvan, PhD. Stud., University of Petroșani, Petroșani, Romania, contact details (University st. no. 20, Petroșani, Romania fazacasgir@gmail.com)

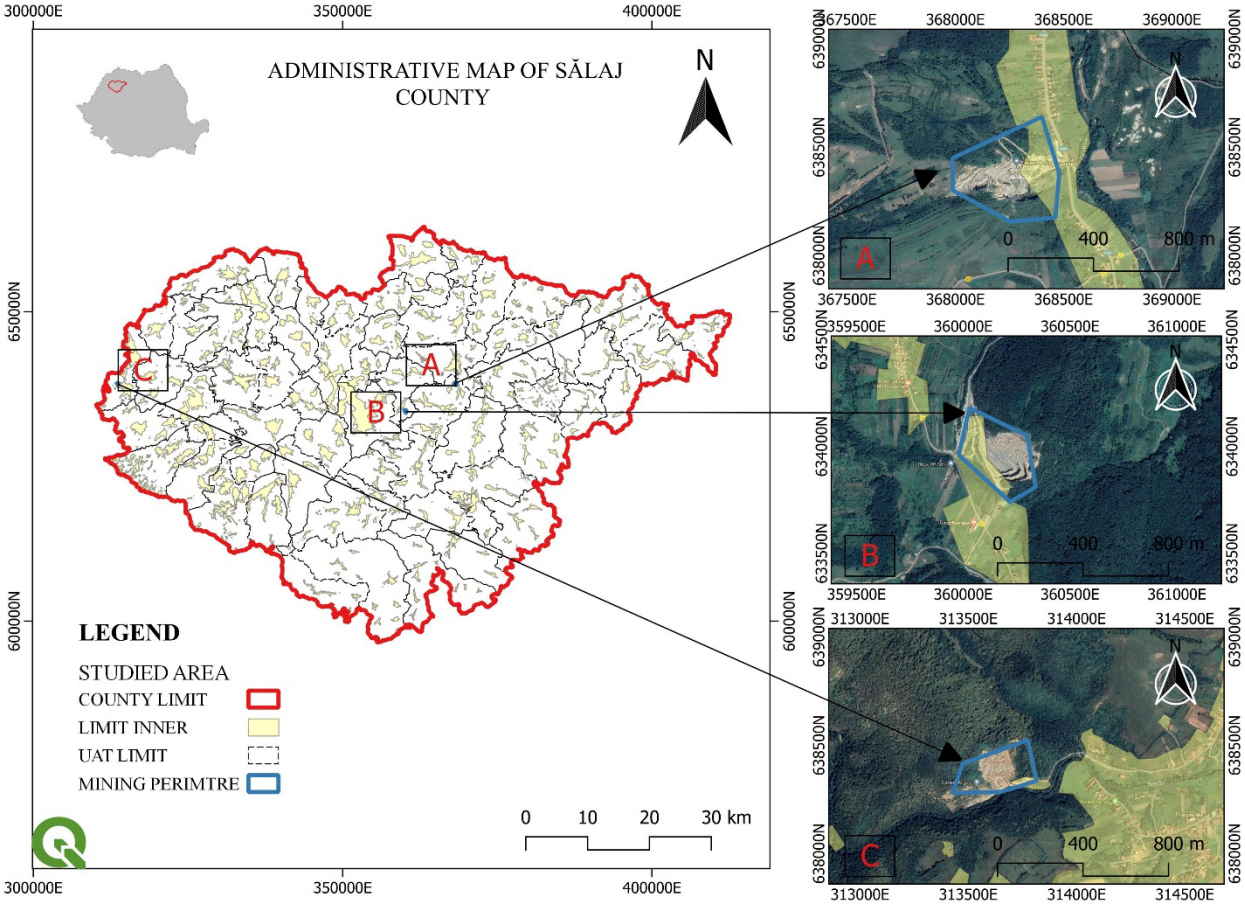

Figure 1. A) Prodănești quarry, B) Moigrad quarry, C) Marca quarry,.Salaj County

2. Materials and methods

In order to determine the sources of pollution, specific equipment was used for sampling and measuring the air, water and noise environmental factors, for the period 2016-2019, carried out by REANAR accredited laboratories, namely: for the Prodănești quarry, the test reports were made by the ICIA Cluj-Napoca laboratory [8],[9],[10],[11] for the Moigrad quarry the determinations were made by the Sălaj Environmental Protection Agency [12], [14], [16], [18], Someș-Tisa Water Basin Administration Sălaj Water Management System [13], [15], [17], and for the Marca quarry, the determinations were made by the laboratory S.C Minesa - Institute of Research and Design Minesa S.A [19], [20], [21], [22].

A. Equipment used for noise determination:
- sound level meter BRUER&KJAER 2250 L;
- SOLO sound level meter;
- sound level meter DELTA OHM HD2010UC;
- analytical balance.

B. Equipment used for the determination of suspended powders, sedimentable powders:
- Zamelli sampler, ZB1;
- isokinetic probe and sampling pump;
- filter membrane d=0.85µm, ϕ=47 mm.

C. Equipment used, analysis of physical and chemical indicators of water quality:
- sampling probe.

Sampling and analysis methods are according to STAS and current regulations.
water: SR ISO 10523/97, STAS 6953-81, STAS 9187/84, SR7587/96
air: STAS 12.574/'8
noise: STAS 10.009/'88

3. The result of the analyses

The results of the laboratory analysis for the air, water and noise environmental components are described in the tables: 1, 2, 3 and 4, it is found that there are no exceedances of the maximum allowed limits and the environmental legislation in force is respected.

Table 1. Average concentrations of suspended dust in the period 2016-2019

No. Crt.	Quality Indicators	M.U.	Garndemar Quarry	Prodănești Quarry	Marca Quarry	Maximum addmited limits Stas 12574/87
1	powder in suspension	mg/dm^3	0.1	0.03	0.15	0.5
2		mg/dm^3	0.2	0.07	0.08	0.5
3		mg/dm^3	0.1	0.07	0.068	0.5
4		mg/dm^3	0.4	0.09	0.1	0.5
5		mg/dm^3	0.1	0.03	0.15	0.5
	sedimentable powder	g/m^3 (30 days)		7.81		17

Table 2. Average concentrations of water quality indicators in the period 2016-2019

No. Crt.	Quality Indicators	M.U.	Moigrad Quarry	Marca Quarry	Maximum addmited limits
1	PH	unit pH	7.02	7.8	6.5-8.5
2	suspended matter	mg/dm^3	16.2	50	60
3	fixed residue	mg/dm^3	118	113	2000
4	extra-attainable substances	mg/dm^3	8.8	<20	20

Table 3. Average noise level for the period 2016-2019

No. Crt.	Analysis point	M.U.	Average of measurement values LAeq		Maximum addmited limits STAS 10.009/'88
			Prodănești Quarry*	Marca Quarry**	
1	crushing activity*	dB(A)	52.7	59.06	65
2	the main gate of the factory*		56.0	46.5	
3	boundary*		54.2	51.83	
4	the southern boundary of the access perimeter to the quarry**		40.0	58.29	

Table 4. Average noise level for the Moigrad quarry period 2016-2019

No. Crt.	Analysis point	M.U.	Average of measurement values Laeq	Maximum addmited limits STAS 10.009/'88
1	to the north towards the dwelling houses	dB(A)	58.4	65
2	to east at career entry, treadmill		59.7	
3	to south of entry into the quarry		63.6	
4	to the west stage of the exploitation quarry		57.6	

4. Environmental impact assessment for the Prodăneşti, Moigrad and Marca quarries

4.1 Matrix environmental impact assessment for the environmental factors air, water and noise

In order to report the environmental components affected by the quarrying activity, the MERI (Rapid Impact Assessment Matrix) method was applied [23]. The MERI method is based on a standard definition of the important evaluation criteria and the means by which quasi-quantitative values can be deduced for each of these criteria Table 5 [23]

The calculation procedure for MERI assumes the following equations:

$$A1 \times A2 = At$$
$$B1 + B2 + B3 = Bt \quad (1)$$
$$At \times Bt = SM$$

where:

A1, A2, B1, B2, B3 – evaluation criteria by the MERI method
At, Bt – marks obtained by multiplying, respectively, adding the values of the evaluation criteria
SM - average score for the analyzed factor

The established standard evaluation criteria fall into two broad types:
A – criteria that can individually change the environmental score obtained
B – criteria that individually cannot change the average score

Table 5. Evaluation criteria and stages by the MERI method

Criterion	Scale	Description
A1 Importance of environmental change (effect)	4	Important for national/international interests
	3	Important for regional / national interests
	2	Important also for areas in the immediate vicinity of the site area
	1	Important only for local conditions
	0	Without importance
A2 Magnitude of environmental change	3	Important major benefit
	2	Significant improvement of the actual / current state
	1	Improving the current state
	0	Unchanging the current state
	-1	Negative change of fact
	-2	Disadvantages or significant negative changes
	-3	Disadvantages or major negative changes
B1 Residence	1	No changes
	2	Temporary
	3	Permanent
B2 Reversibility	1	No changes
	2	Reversible
	3	Irreversible
B3 Cumulativeness	1	No changes
	2	Non-cumulative / unique
	3	Cumulative / synergistic

After obtaining the environmental scores, they are transformed into impact categories (IC), based on the conversion scale in table 6 [23]

Table 6. Conversion of environmental scores into impact categories

Environmental score (ES)	Categories (Code)	Description of the impact category (IC)
+ 72 → + 108	+ E	Major positive impact
+ 36 → + 71	+ D	Significant positive impact
+ 19 → + 35	+ C	Moderate positive impact
+ 10 → + 18	+ B	Positive impact
+ 1 → + 9	+ A	Slightly positive impact
0	N	Lack of change / status quo / Not applicable
- 1 → - 9	- A	Slightly negative impact
- 10 → - 18	- B	Negative impact
- 19 → - 35	- C	Moderate negative impact
- 36 → - 71	- D	Significant negative impact
- 72 → - 108	- E	Major negative impact

The result of the calculation of the impact on the environmental component air, water and noise for the Prodăneşti, Moigrad and Marca quarries, evaluated by the MERI method, was carried out according to the input data and calculation formulas from Table 5, are presented in Tables 7; 8; 9 [24]

Table 7. Evaluation by the MERI method Prodănești quarry

Environment component	Evaluation criteria					Environmental score	Categories (Code)	Description of the impact category (IC)
	A1	A2	B1	B2	B3			
AIR	1	-1	2	3	2	-7	–A	Slightly negative impact
NOISE	1	-1	2	3	2	-7	–A	Slightly negative impact

Table 8. Evaluation by the MERI method Moigrad quarry

Environment component	Evaluation criteria					Environmental score	Categories (Code)	Description of the impact category (IC)
	A1	A2	B1	B2	B3			
AIR	1	-1	2	3	2	-7	- A	Slightly negative impact
WATER	1	-1	2	3	2	-7	- A	Slightly negative impact
NOISE	1	-1	2	3	2	-7	- A	Slightly negative impact

Table 9. Evaluation by the MERI method Marca quarry

Environment component	Evaluation criteria					Environmental score	Categories (Code)	Description of the impact category (IC)
	A1	A2	B1	B2	B3			
AIR	1	-1	2	3	1	-7	- A	Slightly negative impact
WATER	1	-1	2	3	1	-7	- A	Slightly negative impact
NOISE	1	-1	2	3	1	-7	- A	Slightly negative impact

After calculating the assessment using the MERI method, it results that the exploitation activity in quarries has a slight negative impact for all environmental factors WATER, AIR and NOISE,

4.2. Assessment of the impact of the risk produced on the environmental components air, water and noise

The environmental impact and risk assessment process is an important tool in the decision-making process [25], in this case for the studied quarries Prodănești, Moigrad and Marca using a method of evaluation MERI method (Rapid Impact Assessment Matrix) [24]

In the first step, the degree of GI importance is established, for the environmental components air, water and noise in order to be able to assess the impact and the environmental risk to which it is granted on a scale from 0 to 1, where the value 1 represents the highest importance [23], then the units of importance of the UI are calculated for each environmental component example Table 10 [24]

Table 10. Calculation of the importance of each environmental component

CM environmental component	GIi degree of importance	Units of importance UI =1000*GIi/GI
Air	1,00	333
Water	1,00	333
Noise	1,00	333
Total	GI= ∑GIi=3	GI= ∑GIi=1000

In order to assess the environmental impact and risk, it is necessary to analyse the three water, air and noise environmental components described in Table 12, where the quality of the assessed environmental component (Q) is determined as the ratio of the maximum permissible concentration (AQC), according to the legislation in force, to the concentration determined in the environment (Cdet) at a given time for a given pollutant [23]

$$Q = CMA/ C_{det} \quad (2)$$

The induced impact on each assessed environmental component (IM) is given by the product between the quality of the environmental component (Q) and the units of importance (UI) obtained by each environmental component according to the relationship: [23]

$$IM=Q\times UI \quad (3)$$

$$IM= \sum IM/n \quad (4)$$

n – total number of quality indicators analysed.

For each environmental component, an environmental risk is associated and is calculated by the relationship:

$$RM=IM \times P \quad (5)$$

P- the calculated probability that the impact will occur on the environmental component

The probability of an impact on the environmental components analysed is described in Table 11 [23] and correlated with the values in Table 10.

Table 11. Description of probability

Probability	Description	Units of probability
For sure	is carried out in 99% of cases	0,91-1,0
Almost certainly	it could be done in 90% of cases	0,61-0,9
Probable	it can happen in 50% of cases	0,31-0,6
Unlikely	it happens sometimes in 10% of cases	**0,05-0,3**
Rar	it can happen in exceptional cases,1%	<0,05

Table 12. Calculation of environmental impacts and risks

Environment component	The objective under analysis	Quality Indicators	CMA[1]	Cdet[2]	Q[3]	UI[4]	IM[5]	P[6]	RM[7]
Air	Moigrad quarry	powder in suspension	0.5	0.2	2.5	333	832.5	0.3	249.8
	Prodănești quarry	sedimentable powder	17	7.8	2.2		724.8		217.5
	Marca quarry	powder in suspension	0.5	0.1	4.5		1513.6		454.1
	Induced environmental impact and risk ∑ IM/n						**1023.7**		**307.1**
Water	Prodănești quarry	PH	6.5-8.5	7.0	0.9	333	309.2	0.3	92.8
		suspended matter	60	16.2	3.7		1233.3		370.0
		fixed residue	2000	118	16.9		5644.1		1693.2
		extra-attainable substances	20	8.8	2.3		756.8		227.0
	Marca quarry	PH	6.5-8.5	7.8	0.8		277.5		83.3
		suspended matter	60	50.0	1.2		399.6		119.9
		fixed residue	2000	113.0	17.7		5893.8		1768.1
	Induced environmental impact and risk ∑ IM/n						**2073.5**		**622.0**
Noise	Prodănești quarry	crushing activity	65	52.7	1.2	333	410.7	0.3	123.2
		the main gate of the factory		56.0	1.2		386.5		116.0
		boundary		54.2	1.2		399.4		119.8
				40.0	1.6		541.1		162.3
	Marca quarry	the southern boundary of the access perimeter to the quarry	65	59.1	1.1		366.5		109.9
				46.5	1.4		465.5		139.6
				51.8	1.3		417.6		125.3
				58.3	1.1		371.3		111.4
	Moigrad quarry	to the north towards the dwelling houses	65	58.4	1.1		370.6		111.2
		to east at career entry, treadmill		59.7	1.1		362.6		108.8
		to south of entry into the quarry		63.6	1.0		340.3		102.1
		to the west stage of the exploitation quarry		57.6	1.1		375.8		112.7
	Induced environmental impact and risk ∑ IM/n						**400.7**		**120.2**

1*– maximum permissible concentration under the national legislation in force,* ***2*** *– concentration determined,* ***3*** *– quality of the environmental component, depending on indicator "i" from "n" quality indicators;* ***4*** *– the unit of importance obtained by the environmental component;* ***5*** *– the environmental impact calculated according to the parameter "environmental quality",* ***6*** *– the calculated probability that the impact will occur on the environmental component;* ***7*** *– the environmental risk associated with each impact.*

Calculate simultaneously the impact as well as the associated environmental risk for each environmental component air, water and noise for the oebictives analysed after the relationship: [24]

$$IM_{med}=\sum IM_j /m \text{ și } RM_{med}=\sum RM_j/m \quad (6)$$

m- number of environmental components j- analyzed

The quantification of the environmental impact and risk for each environmental component analyzed water, air and noise is classified according to the Table 12 [23].

Table 13. Classification of environmental impact and risk

Environmental impact	Description	Environmental risk	Description
<100	degraded environment, unsuitable for life forms	<200	major risks, preventive measures are needed
100-250	environment severely affected by human activities		
250-350	environment subject to the effects of activities human causing disorders of life forms	200-350	medium risks, preventive measures are needed
350-500	environment exposed to the effects of human activities causing discomfort	350-700	average risks at an acceptable level, must be monitored
500-1000	environment subject to the effects of activities human within permissible limits	700-1000	risks, but must be considered/monitored
>1000	unaffected by activities human/natural quality	>1000	negligible/insignificant risks

By calculating the average value for the three environmental components air, water and noise, an average impact **IM=1166** is obtained, which is classified in the environment unaffected by human activities/natural quality and an average risk **RM=350** is classified into average risks at an acceptable level, prevention and monitoring measures.

After calculating the IM and RM at the activities carried out at the Prodănești quarries. Moigrad and Marca draw the following conclusions regarding the environmental components air, water and noise after the classification in Table 13.

- by air environment component = > an environment unaffected by human activities/natural quality
- by water environment component = > an environment unaffected by human activities/natural quality
- after the environmental component noise = > medium exposed to the effects of human activities causing discomfort

4.3. Remedial measures for environmental factors and the way the quarries are operated

- Maintenance of guard ditches by unclogging in order to ensure their optimal functionality.
- Slope of the berms at the fertile soil dump and tailings dump in order to prevent the appearance of ravines on their slope.
- Maintenance of the existing decanters in the quarries in order to operate at the designed parameters.
- Permanent spraying of access roads to minimize the entrainment of suspended dust.

5. Conclusions

The activity of the quarries analyzed has both local and national economic importance. Analyzing only the environmental components affected by these exploitations, namely air, water and noise using the MERI method and based on the data provided by the verified operators, resulted in a slightly negative impact for the three environmental components analyzed.

Periodic monitoring of the affected environmental components is required, as well as the implementation of the works provided for in the environmental restoration plan and the approved exploitation technology, respectively the geometric elements of the quarries (surface, slope angles, berm width).

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