IMPACT OF MONTANE ENVIRONMENTAL LOADS ON THE ENVIRONMENTAL QUALITY OF THE SLOVAK REPUBLIC

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ABSTRACT

Environmental burdens are currently a significant determinant ofenvironmental quality. The occurrence of montane environmental burdens affects the environmental quality at the local, regional and supraregional levels, mostly to a negative extent. Environmental pollution, due to montane environmental burdens is accompanied by a reduction in environmental quality in all spheres of anthropogenic existence. It is for this reason that the presented article studies the occurrence of montane environmental burdens and their impact on environmental quality in individual regions of the Slovak Republic. In the analyses Analytic Hierarchy Process a multi-criteria decision-making method based on values of the weights in terms of the principles of the Saaty matrix – a quantification of synergistic interactions of indicators. The study concentrates on selected comparative years 2008, 2012, 2017 and 2021 and includes a matrix of their elimination. The results present a categorization of montane environmental loads in the Slovak Republic into categories of the environmental load (from very low to very high) on the environmental quality. In the summary matrix of a comprehensive assessment of montane environmental loads, negative indicators (55.65%) prevails over positive ones (44.35%) with a total scoring ratio of 0.80, i.e. III. category, the average impact on environmental quality.

Keywords: *montane environmental load, environmental quality, matrix, categorization*

INTRODUCTION

Environmental burdens can be understood, also in accordance with Act No. 409/2011 Coll., as any anthropogenic creation that caused an environmental burden, except in cases where the state undertook to rehabilitate the environmental burden based on a contract or on the basis of a decision of the Government of the Slovak Republic or the environmental burden arose as a result of waste landfill which has

complied with the valid permit. However, it should be noted that the obligation of the originator of the environmental burden is, in accordance with the valid legislation of the Slovak Republic, to ensure the elaboration and implementation of the work plan for the removal of the environmental burden. If this does not happen and the environmental burden represents an immediate threat to the health of the population, the relevant ministry will spend the funds for remediation from public sources and subsequently the originator is obliged to pay the funds to the ministry within one year at the latest.

CHARACTERISTICS OF MONTANE ENVIRONMENTAL LOADS

An environmental burden is, in accordance with Act No. 569/2007 Coll. on geological works (Geological Act), "pollution of an area caused by human activity which poses a serious risk to human health or the rock environment, groundwater and soil with the exception of environmental damage". The following two terms are further defined in this Act:

- probable environmental burden – a potentially contaminated site considered to be a burden only on the basis of indications, i.e. the state of the territory where the presence of an environmental burden is reasonably presumed is taken into account,
- environmental burden – a burden confirmed by a survey.

Environmental burdens are currently registered in the so-called Register of Environmental Burdens, which consists of the following four sections [1]:

Section A – so-called probable environmental burdens with direct or indirect indications of contamination at the site, including:

- the presence of sources of contamination,
- records of state administration or self-government bodies on pollution of environmental components or on inappropriate handling of pollutants,
- older archival information on pollution,
- data from selected environmental databases, manifestations of landscape damage – e.g. dead organisms.

Section B – confirmed environmental burdens, which are confirmed by indicative geological survey,

Section C – sites where remediation or reclamation took place, depending on the degree of risk,

Section D – environmental burdens removed from the register.

From the results of the mapping of environmental burdens in the Slovak Republic, there are currently 2054 localities with environmental burdens, with about 15.14% (311) confirmed by survey works, 45.13% (927) probable environmental burdens and 39.73% (816) reclaimed or rehabilitated sites (Table 1).

Sites in which the source of contamination has been eliminated is considered reclaimed, and sites in which new structures and functions of the territory have been created through an appropriate concept of restoration and creation of a new landscape to create an environmentally balanced and aesthetically impressive landscape and environment are considered reclaimed sites.

Table 1. *A comparison of registered environmental burdens in 2008, 2012, 2017 and 2021 in the Slovak Republic (prepared according to [1]).*

Year / Section	2008	2012	2017	2021	index of change 2021/ 2008	index of change 2021/ 2012	index of change 2021/ 2017
A	878	953	882	927	1.06	0.97	1.05
B	257	294	311	311	1.21	1.06	1.00
C	684	713	804	816	1.19	1.14	1.01

Of the total number of environmental burdens, the use of the raw material base consisted of 100 montane environmental burdens, including the processing of minerals and metals, of which 44.0% are probable, 24.0% confirmed and 32.0% reclaimed. The highest number of montane environmental burdens was recorded in the Banská Bystrica Region, where 35.0% (35) of registered environmental burdens (8 confirmed, 18 probable and 9 reclaimed) was allocated and the lowest number was recorded in the Trenčín and Nitra regions, where it was both 2% (2) environmental burdens, while in the Nitra region there were only probable and in the Trenčín region 1 probable and 1 reclaimed montane environmental burden (Figure 1). A 59% share of environmental loads from the exploitation of raw material deposits consisted of loads from raw material mining and 41.1% share from its processing or storage, most of which were environmental burdens from ore mining (36.0%) and the least from ore mining (4.0%) (Figure 2).

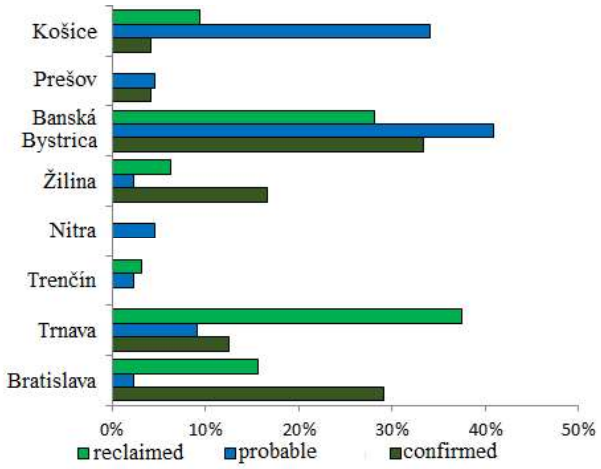

Fig. 1. *Montane environmental burdens in the regions of the Slovak Republic.*

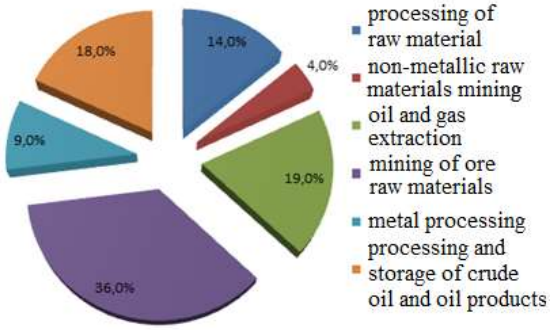

Fig. 2. *Registered montane environmental burden in the Slovak Republic.*

For the needs of environmental risks elimination of the use of the raw material base, Act No. 24/2006 Coll. on Environmental Impact Assessment (EIA) as amended, the aim of which is to explicitly identify measures leading to the preservation or improving environmental quality. The purpose of the mentioned law, which is considered an international instrument of environmental policy, is [2]:

- to ensure the required level of environmental protection in a timely and effective manner and contribute to the promotion of sustainable development,
- to identify, describe and balance the direct and mediated effects of the extraction and processing of minerals on the environment,
- to justify and at the same time compare the advantages and disadvantages of a specific method of mining and its further processing to explicitly define measures leading to the reduction or elimination of environmental quality, or prevention of environmental damage,
- to obtain an expert opinion based on which a decision on the permit (or refusal) of mining or processing of extracted mineral raw material according to special regulations.

ASSESSMENT OF THE IMPACT OF MONTANE ENVIRONMENTAL LOADS ON THE ENVIRONMENTAL QUALITY OF THE SLOVAK REPUBLIC

The comprehensive methodology for the assessment of montane environmental burdens was based on the quantification of synergistic interactions of environmental and socio-economic indicators of the occurrence of montane environmental burdens, which we divided according to their impact into two groups of indicators affecting positive and negative environmental quality in the Slovak Republic.

Analytic Hierarchy Process (AHP) is a multi-criteria decision-making method, developed by mathematician Thomas L. Saaty. It is a tool that can be applied in various areas of planning and management [3]. It was applied in evaluations of urban landscape management problems [4], [5], [6], [7]. AHP uses a pairwise

comparison method for generation of criteria weightings (ratio scales), instead of a simple listing and ranking of the importance levels [8].

From the previous experience and the results of the analyzes, 14 positive and 14 negative indicators of the exploitation of raw material deposits were identified. They are characterized by reversible and irreversible impacts on the environment, in terms of promoting sustainable development. A quantification of synergistic interactions of indicators by numerical expressing of their prioritization through their weights – α_i was realized. The numerical value of the weights α_i for all indicators, accepting the generally valid condition $\sum\alpha_i = 1$, was determined. The values of the weights in terms of the principles of the Saaty matrix, whose dimensions m x n, where $m = 1 \ldots i$ and $n = 1 \ldots j$, were given by the number of rows and columns, while observing the condition m = n, were quantified. This symmetrical shape of the matrix also corresponds to the fact that the method is based on an interactive comparison of all defined indicators of the same order with the evaluation in Table 2 [9].

Table 2. *Evaluation of negative and positive indicators in the Saaty matrix.*

Determinant Value	Description of Comparative Determinants
1	Determinants *i* and *j* are equivalent
3	The determinant *i* is slightly preferred over the determinant *j*
5	The determinant *i* is strongly preferred over the determinant *j*
7	The determinant *i* is very strongly preferred overthe determinant *j*
9	The determinant *i* is absolutely preferred over the determinant *j*

Subsequently, the value of 1 was plotted on the diagonal of the matrix, as the principle of comparison of the same indicators, i.e. their equivalence was accepted, and pairwise comparisons of individual indicators were identified. If the indicator listed in the row is preferred over the indicator listed in the column, a reciprocal value was assigned. After evaluating the individual indicators in this way, partial products of the lines were created according to the relation:

$$S_i = \prod_{j=1}^{f} S_{ij}, \; j = 1, 2, 3, \ldots f, \quad (1)$$

f – number of factors,

S_{ij} – individual factors.

Further the value of R_i for each criterion, i.e. row of created matrix was quantified according to formula:

$$R_i = (S_i)^{\frac{1}{f}} \quad (2)$$

Based on calculations, the sum of R_i was calculated, based on which the final value of individual weights α_i were quantified reflecting the mutual interactions of the compared indicators of the use of the raw material base and their prioritization in the process of supporting sustainable development.

Table 3. *Negative indicators of the impact of environmental burdens.*

Indicator / Interaction	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	S_i	R_i	α_i
I1	1	3	5	3	3	3	3	3	3	5	54.675	2.98	0.24
I2	1/3	1	1	1/3	1	1/3	1/3	1	1	1/3	0.004	0.58	0.05
I3	1	1	1	1	3	1	3	3	3	1	81	1.55	0.12
I4	1/3	3	1	1	1	1/3	1/3	1/3	1	1	0.037	0.72	0.06
I5	1/3	1	3	1	1	1/3	1	1	1/3	1/3	0.037	0.72	0.06
I6	1/3	3	1	3	3	1	3	3	1	1	81	1.55	0.12
I7	1/3	3	3	3	1	1/3	1	1	1	1	3	1.12	0.09
I8	1/3	1	3	3	1	1/3	1	1	1	1	1	1.00	0.08
I9	1/3	1	1	1	3	3	1	1	1	1	3	1.12	0.09
I10	1/5	3	1	1	3	3	1	1	1	1	5.4	1.18	0.09
SUM												**12.51**	**1.00**

NOTE: S_i, R_i, α_i were defined in Eq. (1) and (2).

In terms of the above methodological procedure, the weights – α_i to negative indicators were explicitly quantified (Table 3), including [9], [10]:

- I1 – impact on the public health,
- I2 – impact on the environment,
- I3 – impact on the air,
- I4 – impact on hydrogeological conditions,
- I5 – impact on biotic components of the environment,
- I6 – impact on protected areas in accordance with applicable legislation,
- I7 – impact on the territorial system of ecological stability,
- I8 – impact on the landscape–aesthetic character of the environment,
- I9 – impact on urban complex,
- I10 – production of mining waste, which is classified in accordance with applicable legislation as hazardous waste.

Using an analogous procedure, the weights – α_i to positive indicators (Table 4) were explicitly quantified, while the possibilities resulting from the revitalization of montane environmental loads were included as follows [9], [10]:

- I1 – existing transport infrastructure,
- I2 – existing technical infrastructure,
- I3 – existing production facilities,
- I4 – existing administrative buildings,
- I5 – support for regional development,
- I6 – impact on the living standards of the population,
- I7 – increasing environmental quality,
- I8 – improving the aesthetic character of the landscape,
- I9 – positive effect on environmental health.

Table 4. *Positive indicators of the impact of environmental burdens.*

Indicator / Interaction	I1	I2	I3	I4	I5	I6	I7	I8	I9	S_i	R_i	α_i
I1	1	1	1/3	5	1/3	1/3	1	1/5	1/5	0.0074	0.58	0.06
I2	1	1	1/5	1/3	1/3	1/5	1/3	1	1	0.0015	0.49	0.05
I3	3	5	1	1/3	1/5	1/3	1/3	7	5	3.8889	1.16	0.12
I4	1/5	3	3	1	1/3	1/3	1/3	1/5	1	0.0133	0.62	0.06
I5	3	3	5	3	1	1	1/3	1/5	1	9	1.28	0.13
I6	3	5	3	3	1	1	3	1/3	1/3	45	1.53	0.15
I7	1	3	3	3	3	1/3	1	1/3	1	9	1.28	0.13
I8	5	1	1/7	5	5	3	3	1	5	803.5714	2.10	0.21
I9	5	1	1/5	1	1	3	1	1/5	1	0.6	0.94	0.09
SUM											**9.97**	**1.00**

NOTE: S_i, R_i, α_i were defined in Eq. (1) and (2).

Constructing the summary matrix of a comprehensive assessment of montane environmental loads on the environmental quality of the Slovak Republic (Table 5), negative indicators (55.65%) showed a slight superiority over positive ones (44.35%) with a total scoring ratio of 0.80 based on which the category of impact on the quality of the environment could also be predicted. It was identified as III. category, i.e. average impact on environmental quality, as the scoring ratio reached 0.80.

Table 5. *The impact of montane environmental loads on the environmental quality of the Slovak Republic.*

Indicator / Interaction	Deter-minant	Partial score	Score	Scoring rate
impact on the public health	-	13.24	55.65	**0.80**
impact on the environment	-	2.57		
impact on the air	-	6.90		
impact on hydrogeological conditions	-	3.20		
impact on biotic components of the environment	-	3.20		
impact on protected areas in accordance with applicable legislation	-	6.90		
impact on the territorial system of ecological stability	-	4.96		
impact on the landscape-aesthetic character of the environment	-	4.45		
impact on urban complex	-	4.96		
production of mining waste, which is classified in accordance with applicable legislation as hazardous waste	-	5.26		
existing transport infrastructure	+	2.58	44.35	
existing technical infrastructure	+	2.16		
existing production facilities	+	5.17		
existing administrative buildings	+	2.75		
support for regional development	+	5.68		
impact on the living standards of the population	+	6.79		
increasing environmental quality	+	5.68		
improving the aesthetic character of the landscape	+	9.35		
positive effect on environmental health	+	4.20		

Table 6. *Categorization of the impact of environmental burdens on environmental quality.*

Category of impact of montane environmental loads		Degree of impact
I. category	Very low impact	**Above 1.80**
II. category	Low impact	**1.79 – 1.30**
III. category	Average impact	**1.99 – 0.80**
IV. category	High impact	**0.79 – 0.30**
V. category	Very high impact	**0.29 and less**

CONCLUSION

The exploitation of mineral deposits forms the basic platform for the functioning of all national economic sectors of the Slovak Republic, which is determined by the development and dependence of the primary, secondary and tertiary spheres of individual sectoral economies of the Slovak Republic. The actual exploitation of mineral deposits is accompanied by the emergence of montane environmental burdens, which negatively affect the environmental quality, environmental health and regional development in the Slovak Republic with other negative manifestations in the socio-economic sphere. In the analyses Analytic Hierarchy Process a multi-criteria decision-making method based on values of the weights in terms of the principles of the Saaty matrix – a quantification of synergistic interactions of indicators. The study concentrates on selected comparative years 2008, 2012, 2017 and 2021 and includes a matrix of their elimination. The results of quantitative analyzes of the occurrence of montane environmental burdens pointed to their fluctuating development trend with the highest occurrence in the Banská Bystrica region and the lowest in the Trenčín and Nitra regions.

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