IJE TRANSACTIONS C: Aspects Vol. 34, No. 6, (June 2021) 1548-1559

International Journal of Engineering

Journal Homepage: www.ije.ir

An Application of Fuzzy-VIKOR Method in Environmental Impact Assessment of the Boog Mine Southeast of Iran

S. Tabasi*, G. H. Kakha

Faculty of Industry & Mining (Khash), University of Sistan and Baluchestan, Zahedan, Iran

P A P E R I N F O

Paper history:
Received 01 March 2021
Received in revised form 03 April 2021
Accepted 19 April 2021

Keywords:
Boog
Environmental Component
Environmental Impact Assessment
Fuzzy Data
Impacting Factor
VIKOR

A B S T R A C T

Mining activities are one of the essential environmental challenges. Rating the environmental components (ECs) that affect by mining activities is a strategic guide for Environmental-Impact-Assessment (EIA). VlseKriterijumska- Optimizacija- I- Kompromisno- Resenje (VIKOR) method is developed as an efficient decision-making method to assess the impacts of the granite quarry Boog (in Southeast of Iran) on the environment. VIKOR method focuses on quantifying the effect of each impacting factor (IF) on each designed EC. This paper represents an evaluation method relying on fuzzy numbers in decision methods to carry out the lack of certainty and ambiguity from experts' subjective knowledge and experience. Shannon entropy theory is used to adjust subjective weights defined by decision makers to objective weights. The results catched through ranking the R, S and Q indices. In this case, the Air quality (R= 0.05, S= 0.16, Q= -0.05) is available as the more important EC that affected by the mining activities contaminations. Compareing the results with standard matrix method confirm that the Air quality has been effected more than the other parameters with 33.63%. Fuzzy-VIKOR is a systematic approach, which can easily extend to deal with quantitative environmental analysis and other mining engineering selection problems.

***doi**: 10.5829/ije.2021.34.06c.19*

NOMENCLATURE

f_i^+	The best rating of all attributes	TFNs	Triangular fuzzy numbers
f_i^-	The worst rating of all attributes	$\tilde{f}_i^*$	Positive triangular ideal solution
S_i	The maximum usefulness of alternatives groups	$\tilde{f}_i^0$	Negative triangular ideal solution
R_i	The minimum individual alternative.	$\tilde{d}_{ij}$	Normalized fuzzy difference
Q_i	VIKOR index	$\tilde{a}_{ij}$	Expert opinions converted to TFNs
A_m	Ranked alternatives	**Greek Symbols**	
e_j	Entropy measure	α_{ij}	Lower bound of expert opinion
div_j	Degree of divergence	δ_{ij}	Geometric mean of expert opinion
w_j	Objective weight	γ_{ij}	Upper bound of expert opinion
IFs	Impacting factors	λ	Numbers of experts
ECs	Environmental components	β_{ijk}	TFNs used for evaluation the effect of each IF on each designed EC

1. INTRODUCTION

Along with world economic growth, sustainable development (SD), has sought to generate a continuous balance through economic, social growth and the environment protection [1, 2]. Over the last decades, there have been remarkable interests in environmental issues. The emphasis of SD is now widely on human activities that cause environmental pollution. Mining activities with the acquisition of various kinds of natural resources, have a number of common stages, each of

*Corresponding Author Institutional Email: somayehtabasi@eng.usb.ac.ir (S. Tabasi)

Please cite this article as: S. Tabasi, G. H. Kakha, An Application of Fuzzy-VIKOR Method in Environmental Impact Assessment of the Boog Mine Southeast of Iran, , International Journal of Engineering, Transactions C: Aspects Vol. 34, No. 6, (2021) 1548-1559

which has potentially adverse impacts on the natural environment [3]. Every mining activity changes and disturbs, more or less, the condition of the natural environment by mainly energy consumption, deformations of the earth, various changes of water relations, emission of gas, dust and noise and the others [4,5]. Hence, it is necessary to use Environmental-Impact-Assessment (EIA) as an ongoing process, identifying the potential impacts of mining activities on the environment and reducing environmental problems for keeping mining activities in line with the principles of SD [6].

A technique and process that collects information about the environmental consequences of a project in advance, is an operational definition of EIA. Understanding these impacts can provide a suitable plan to prevent and reduce the hazardous effects. Since 1970, EIA has been set up as a powerful tool for environmental protection in projects planning process [7]. Today, EIA is essential for identifying all positive and negative impacts of industrial and mining activities on the surrounding environment [1]. Impact prediction's methods vary based on EIA components both qualitatively and quantitatively. Several standard techniques such as checklists, matrices, flowcharts and networks, mathematical/statistical models can be used to assess environmental components (ECs) [8]. In recent years, new tools and techniques such as mapping software and geographical information systems (GIS), remote sensed data were completed and support the EIA process [9].

Leopold et al. [10]. introduced one of the first EIA's evaluation methods Leopold matrix is a simple and efficient method that evaluates the project activities affects on the surrounding environment [11]. Pastakia [12] introduced the Rapid- Impact- Assessment- Matrix (RIAM) technique that alternatives rapidly evaluate without qualitative judgments. Pastakia and Jensen [13] used Rapid- Impact- Assessment- Matrix (RIAM) to provide clear reports that were well-informed. Phillips [14] developed a concept of SD index based on Rapid-Impact- Assessment- Matrix (RIAM) method. Folchi matrix, in contrast to Leopold's matrix, is quantitative and present a numerical judgment [15]. RIAM and Folchi methods did not consider the positive impacts of the project [16]. D-number method developed in order to reduce the uncertainty of the EIA methods and later modified by Wang and Wei [17]. As impacts of the components should take into account simultaneously during EIA, multi-criteria/multi-attribute- decision-analysis (MCDA/MADA) enables an analysis of different aspects of project impacts [18,19]. Decision making is the procedure of detecting the first rated option among the feasible choices; however, if decision-makers refuse to assess some criteria because of their knowledge limitation or because of the uncertainty of information, this assessment information cannot be recorded by the existing methods [1,19]. Therefore, the improved Analytic- Hierarchy- Process (AHP) and fuzzy- AHP, are extended into the MCDM methods to handle EIA problems [20]. Saffari et al. [1] merged ''Fuzzy Delphi'' and ''Folchi'' as an efficient tool in EIA systems with uncertainty.

Recently, some researchers extend the VIKOR (VlseKriterijumska- Optimizacija- I- Kompromisno-Resenje) method either solely or along with other mathematical techniques such as Analytic- Hierarchy-Process (AHP), Analytic- Network- Process (ANP) and Artificial Neural Networks (ANN) to provide decision-making problems with interval data [21].

The main objective of the proposed research is to develop an appropriate EIA method for monitoring the environmental disturbances result from mining activities of the granite quarry Boog. This framework uses fuzzy Logic, VIKOR and Shannon Entropy concept to prevent uncertainties in data and subjectivity in decision-makers opinions. This systematic approach transforms the quantitative and qualitative data into a equivalent scale and improves the ECs prioritizing. EIA's data can use to measure the interrelationships among the SD components and determine the sustainability level of mining activities.

Range from simple to complex, the focus of EIA methods have evolved from generating a list of potential impacts on selected environmental components. The complexity is increased by the diversity of the disciplines. Useful and destructive effective parameters introduced by 0-10 score. The triangular fuzzy numbers (TFNs) were used to describe the opinions of the experts about each IF. A matrix of potential interactions is produced by combining IFs and ECs (placing one on the vertical axis and the other on the horizontal axis). Linguistic values are converted to fuzzy numbers and used as the input for the fuzzy- VIKOR method. In next stage, in order to have comparable criteria, the fuzzy decision matrix is normalized. The Shannon Entropy concept is deploy to derive objective weights. The VIKOR method is used to calculate the positive and negative points of solution and finally the alternatives are ranked by sorting the values R, S and Q in descending order. The alternative with minimum value of Q is the best alternative and the compromise solution could be obtained.

2. MATERIALS AND METHODS

2. 1. VIKOR Method The VIKOR method was extended in 1998 by Opricovic to solve MADM problems with inconsistent and uncertain criteria [22,23]. VIKOR introduces the compromise ranking index based on the closeness rating of all alternatives to the best ideal alternative using linear normalization to remove units of rule functions [24]. Where the DM at the initial phase of the MCDM process is not able to express his/her preference, the VIKOR method is effective [25]. This multi- attributes measurement use for agreement rating and extend based on the Lp-metric, as a summation function, [26] is shown as follow:

$$L_{p,i} = \left\{ \sum_{j=1}^{n} [w_j (f_j^* - f_{ij}) / (f^* - f_j^-)]^p \right\}^{1/p} \quad (1)$$
$$1 \le p \le \infty;$$
$$i = 1, 2, ..., m$$

where f_{ij} is the evaluation value of attribute j for alternative i; f_j^* and f_j^- are the best and worst value of alternative j, respectively; w_j is attribute weight; m and n are the number of attributes and alternatives respectively; the weight of the maximal deviation from the ideal solution denotes by p.

The VIKOR method deploys $L_{1,i}$ (as S_i in Equation (3) and $L_{\infty,i}$ (as R_i in Equation (4)) in order to formulate the ranking measure. Si is represents the maximum usefulness of alternatives groups, while Ri represents the minimum individual alternative. The main procedure of the VIKOR method comprises of some steps to find a solution of the problem described below [24]:

Step 1: Define Rating

The best f_i^+ and the worst f_i^- rating of all attributes determine using the following formulas:

$$f_i^+ = \max_i f_{ij}$$
$$f_i^- = \min_i f_{ij} \quad (2)$$

Step 2: Calculate Si and Ri Values

$$S_i = \sum_{j=1}^{M} w_j \left(\left[f_j^+ - (f_{ij}) \right] / \left[f_j^+ - f_j^- \right] \right) \quad (3)$$

$$R_i = \max_j of (w_j \left[f_j^+ - (f_{ij}) \right] / \left[f_j^+ - f_j^- \right]) \quad (4)$$
$$| j = 1, 2, ..., M$$

Step 3: Compute Values of Q_i

Values of VIKOR indices (Q_i) calculate as follows:

$$Q_i = v((S_i - S^-)/(S^+ - S^-))$$
$$+(1-v)((R_i - R^-)/(R^+ - R^-)) \quad (5)$$

where

$$S^+ = \max_i S_i$$
$$S^- = \min_i S_i$$
$$R^+ = \max_i R_i \quad (6)$$
$$R^- = \min_i R_i$$

v is introduce as the weight of the decision-making of the major criterion, can take any value from 0 to 1. Generally, the quantity of v is 0.5 [27].

Step 4: Rank the Alternatives

The alternatives rank by sorting the S, R and Q quantities in the descending order. For a given value of v, the compromise-ranking list obtaine by Q_i values ranking. In this list, the alternative with the minimum value of Q_i, is the best alternative.

Step 5: Compromise Solution

Propose alternative A_1 which is the first ranked by the Qi values as an agreement solution by fulfilling the two following C1 and C2 states:

C1: "Acceptable Advantage"

Considering A_2 as the second best alternatives based on the Q_i values, the relation $Q(A_2) - Q(A_1) \ge (1/N - 1)$ should be established.

C2: "Acceptable Stability in Decision Making"

Established decision- making should be checked. So alternative A_1 must also be the formest rated based on ranking lists of both or at least one of the *S* or/and *R* values. This agreement is stable within a decision-making process and by following intervals of v:

$$\begin{cases} \text{the vote is by } \textit{major rule} & v \succ 0.5 \\ \text{the vote is by } \textit{consensus} & v \approx 0.5 \\ \text{the vote is by } \textit{veto} & v \prec 0.5 \end{cases}$$

different perspectives in decision-making can be stimulated.

Two following agreements propose, if one of the C1 and C2 states is not satisfied [28]:

Choose alternatives A_1 and A_2 if only C2 is not satisfied.

Choose alternatives A_1, A_2, ..., Am if C1 is not satisfied, wherein A_m is determined by using equation $Q(A_m) - Q(A_1) \prec (1/N - 1)$ for maximum m value that meets the sets of Qi.

2. 2. Fuzzy Logic Zadeh [29] first introduced fuzzy set theory that trace lingual variables to numerical ones within decision-making processes. Fuzzy Multi-Criteria- Decision-Making (FMCDM) method use to rate alternatives and assigne the weights of criteria in the cases with low precision [30].

A fuzzy set is a category of objects with no boundary between them. Membership function within the interval [0, 1], states the degree of belonging of each element to the fuzzy set [31].

The fuzzy set

$$M = \{(\chi), \mu_M(\chi), \chi \in R\} \quad (7)$$

describes fuzzy numbers where $\mu_M(\chi)$ is a continued trace from R to closed interval [0,1].

2. 3. Shannon Entropy and Objective Weights

Weighting methods categorize into two categories: in subjective methods the preference of decision makers is the basis of assessing weights, in the other side, objective techniques use mathematical models automatically without individuals preference consideration to specify weights [32].

The conception of entropy is a degree of information, disorder, chaos or uncertainty formulized in terms of likelihood theory. The probability of occurrence of an event is a degree of indeterminacy about the occurrence of this event. An event that occurs with high probability needs less information in order to characterize. On the other hand, more data need to describe the events happen with low probability [33]. Since the logarithm of occurrence probability, p (X_i), of an event, X_i, express the information content of this event thus entropy H(X) can define quantitatively as the probability-weighted average of the information content of each event X_i:

$$H_{shannon} = -\sum_i p_i \log(p_i) \quad (8)$$

This concept can deploy as a weighting calculation method through the following steps [32,34]:

Step 1: Normalizing the Evaluation Index

$$P_{ij} = \frac{x_{ij}}{\sum_j x_{ij}} \quad (9)$$

Step 2: Calculating Entropy Measure of Every Index

For every index, entropy measure calculate using the equation

$$e_j = -k\sum_{j=1}^{n} P_{ij} \ln(p_{ij})$$
$$k = (\ln(m))^{-1} \quad (10)$$

where m is the number of alternatives.

Step 3: Defining the Degree of Divergence

$$div_j = 1 - e_j \quad (11)$$

more degree of the div_j indicates the more important of the criterion j^{th}.

Step 4: Obtaining the Normalized Weights of Indexes

The entropy weighting of an attribute compute as following

$$w_j = \frac{div_j}{\sum_j div_j} \quad (12)$$

2. 4. Impacting Factors and Environmental Components

Some negative influence of mining activity on the environment include the surface and underground water contamination, air pollution, soil properties changing, ecology changing, noise, waste. In order to investigate the environmental impact of the mining activity through different EIA methods many researches have attempted to describe impacting factors (IFs) and environmental components (ECs) [1].

The activities that have destructive effects on the environment are IFs. Some issues of the surrounding environment that affected by the activities are defined as ECs. Each of the IFs can affect one or several ECs [35,16].

3. CASE STUDY

The granite quarry Boog is one of the well-known quarry mines in the southeast part of Iran, is located 85 km from Zahedan City (Iran). Boog mine has a notable affect on the economy, culture and environment of the region.

4. RESULTS AND DISCUSSION

To study the environmental affect of the Boog granite mine, based on expert's idea, IFs and ECs are listed in Tables 1 and 2, respectively [36,1]. Some IFs like dust diffusion, landscape changing, noise pollution have negative impacts (the smaller factors are the better factors) and the activities like local employment, population control, social and cultural growth and environmental arrangements have positive impacts (the larger factors are the better type). In order to designate the influence of IFs on ECs, the affection of every IF on every EC is represented in Table 3 by the six statements from no (N) to very high influence (VH) and as relative numerical values [35,1].

Technical questionaries sent to the nine mining and environmental specialist experts. The impact of each factors on the ECs scored based on Table 3.

TABLE 1. Impacting factors (IFs)

No.	Impacting factors (IF)
1	Changing the usage of the area
2	Exposition of the area
3	Interference with surface water
4	Interference with ground water
5	Increasing the traffic of the area
6	Dust emission
7	Toxic pollutants and substance emissions to air
8	Noise pollution
9	Land vibration
10	Domestic employment
11	Population control policies
12	Social and cultural development
13	Instability of the established spaces
14	Environmental arrangements
15	Light

Environmental assessments process perform by using the decision matrix. IFs and ECs resulted from experts' scores are decision matrix rows and columns respectively and used as the input for the Fuzzy-VIKOR method.

In present research, in order to approximate the subjective opinions of decision-makers effectively, triangular fuzzy numbers (TFNs) used for the lingual terms. Expert opinions converted to TFNs, $\tilde{a}_{ij}$, which express the optimistic, modest and non-optimistic estimation for evaluating the alternatives in relation to each criterion as follows [37,38]:

TABLE 2. Environmental components (EC)

No.	Environmental components (EC)
1	Human health and immunity
2	Social issues
3	Surface water
4	Ground water
5	Air quality
6	Area usage
7	Ecology
8	Surface constructions 9
9	Area landscape
10	Quietness
11	Economic issues
12	Soil of the are

TABLE 3. Numerical values designed for the answered questionnaires [1, 35]

Expression variable	Associated Numerical values
No influence (N)	0
Very low influence (VL)	1
Low influence (L)	2
Medium influence (M)	3
High influence (H)	4
Very high influence (VH)	5

$$\tilde{a}_{ij} = (\alpha_{ij}, \delta_{ij}, \gamma_{ij}) \tag{13}$$

$$\alpha_{ij} = Min(\beta_{ijk}) \qquad k = 1, 2, ..., \lambda \tag{14}$$

$$\delta_{ij} = (\prod_{k=1}^{n} \beta_{ijk})^{1/n} \qquad k = 1, ..., n \tag{15}$$

$$\gamma_{ij} = Max(\beta_{ijk}) \qquad k = 1, 2, ..., \lambda \tag{16}$$

where

$$\alpha_{ij} \le \delta_{ij} \le \gamma_{ij}$$

$$\alpha_{ij}, \delta_{ij}, \gamma_{ij} \subseteq [0, 5]$$

$\alpha_{ij}, \delta_{ij}, \gamma_{ij}$ are lower bound, geometric mean and the upper bound respectively. The numbers of experts are λ. The relative severity of significance of kth expert opinion express among parameters i and j by β_{ijk}. Table 4 shows the results of this step.

The prime stage of fuzzy- VIKOR method is to draw out the positive triangular perfect resolution ($\tilde{f}_i^*$) correspond to positive ideal factors then the negative triangular perfect resolution ($\tilde{f}_i^0$) correspond to negative ideal factors using Equation (2). The results are presented in Table 5.

The next step normalized fuzzy difference ($\tilde{d}_{ij}, j = 1, ..., J, i = 1, ..., n$) was calculated using the following equations respectively for positive and negative IFs:

$$\tilde{d}_{ij} = \frac{(\tilde{f}_i^* - \tilde{f}_{ij})}{(r_i^* - l_i^0)} \tag{17}$$

$$\tilde{d}_{ij} = \frac{(\tilde{f}_{ij} - \tilde{f}_j^*)}{(r_j^0 - l_j^*)} \tag{18}$$

Table 6 shows the normalized fuzzy difference values.

The process of weights estimation is derived using the shannon entropy concept. In order to determine the objective weights by entropy measure, the projection value of each IF calculated using Equation (9) at first. Afterward, the entropy value is calculated by using Equation (10). Then, to calculate the degree of divergence of each IF the Equation (11) deployed. The objective weight for each IF is calculated by using Equation (12). Table 7 shows these calculated amounts.

Weighted sum $\tilde{S}$ and operator MAX $\tilde{R}$ calculated in fuzzy form using Equations (3) and (4), respectively. In order to rate ECs, the magnitude of $\tilde{Q}$ computed using Equation (5).

Then the results are defuzzified to detect crisp S, R and Q values of all ECs (Table 8). All ECs prioritized by a descend rule begin from the greatest crisp values of S, R and Q indices. The results are shown in Table 9. As it is obvious in Table 9, Q ranks Air quality, as the most significant component. The condition one (C1) is satisfied. However, Air quality ranked as the second most significant component by R and the condition two (C2) is not satisfied. So Soil of the area is ranked as equal as Air quality.

TABLE 4. Triangular fuzzy numbers (TFN) used for evaluation the effect of each impacting factor on each designed environmental component according to opinions of experts

	Air quality			**Quietness**			**Ecology**			**Surface water**			**Underground water**			**Area usage**		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
Changing the usage of the area	0.00	0.00	4.00	0.00	0.00	3.00	1.00	2.74	5.00	1.00	2.35	5.00	1.00	2.47	4.00	1.00	2.12	4.00
Exposition of the area	0.00	0.00	4.00	1.00	2.12	4.00	1.00	2.74	5.00	2.00	3.09	5.00	1.00	2.12	4.00	1.00	2.39	4.00
Interference with surface water	0.00	0.00	1.00	0.00	0.00	1.00	1.00	2.47	4.00	1.00	2.47	4.00	2.00	3.19	5.00	1.00	2.12	4.00
Interference with ground water	0.00	0.00	2.00	0.00	0.00	1.00	1.00	2.29	4.00	1.00	2.12	4.00	2.00	2.67	4.00	1.00	2.47	4.00
Increasing the traffic of the area	1.00	2.65	5.00	1.00	2.74	5.00	1.00	2.29	4.00	0.00	0.00	3.00	0.00	0.00	4.00	2.00	2.88	4.00
Dust emission	2.00	3.82	6.00	0.00	0.00	4.00	2.00	3.82	6.00	2.00	2.88	4.00	1.00	1.82	3.00	1.00	1.82	3.00
Toxic pollutants and substance emissions to air	1.00	3.03	5.00	0.00	0.00	4.00	2.00	3.30	5.00	1.00	2.47	4.00	1.00	2.47	4.00	1.00	2.47	4.00
Noise pollution	0.00	0.00	3.00	1.00	2.47	4.00	1.00	1.82	3.00	0.00	0.00	1.00	0.00	0.00	1.00	1.00	2.47	4.00
Land vibration	0.00	0.00	1.00	1.00	2.12	4.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00	1.00	1.82	3.00
Domestic employment	0.00	0.00	4.00	0.00	0.00	3.00	1.00	2.12	4.00	1.00	1.82	3.00	1.00	1.82	3.00	1.00	1.82	3.00
Population control policies	0.00	0.00	4.00	1.00	2.12	4.00	1.00	2.47	4.00	0.00	0.00	2.00	0.00	0.00	4.00	3.00	3.91	5.00
Social and cultural development	1.00	2.12	4.00	1.00	1.82	3.00	1.00	2.12	4.00	1.00	1.82	3.00	1.00	1.82	3.00	2.00	2.88	4.00
Instability of the established spaces	0.00	0.00	1.00	0.00	0.00	1.00	1.00	2.74	5.00	0.00	0.00	1.00	0.00	0.00	1.00	2.00	2.88	4.00
Environmental arrangements	1.00	2.74	5.00	1.00	2.47	4.00	2.00	3.19	5.00	2.00	3.19	5.00	1.00	2.12	4.00	1.00	2.12	4.00
Light	0.00	0.00	1.00	0.00	0.00	4.00	0.00	0.00	4.00	0.00	0.00	3.00	0.00	0.00	4.00	1.00	1.82	3.00

TABLE 4. Continued

	Surface constructions			**Area landscape**			**Soil of the area**			**Human health and immunity**			**Social issues**			**Economic issues**		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
Changing the usage of the area	1.00	1.82	4.00	1.00	2.47	4.00	1.00	2.12	4.00	2.00	3.65	5.00	2.00	3.65	5.00	1.00	2.74	5.00
Exposition of the area	2.00	3.19	4.00	2.00	2.39	4.00	2.00	2.88	4.00	2.00	3.09	5.00	1.00	3.09	5.00	1.00	2.12	4.00
Interference with surface water	1.00	1.82	3.00	1.00	1.74	3.00	1.00	1.82	3.00	1.00	2.47	4.00	1.00	2.47	4.00	0.00	0.00	3.00
Interference with ground water	1.00	1.82	3.00	1.00	1.82	3.00	1.00	1.74	3.00	1.00	2.12	4.00	0.00	2.12	3.00	1.00	1.82	3.00
Increasing the traffic of the area	0.00	0.00	3.00	0.00	1.82	3.00	1.00	1.82	3.00	1.00	2.47	4.00	2.00	2.47	4.00	1.00	2.12	4.00
Dust emission	1.00	2.47	3.00	1.00	1.82	3.00	1.00	1.82	3.00	2.00	3.65	5.00	1.00	3.65	4.00	1.00	2.12	4.00
Toxic pollutants and substance emissions to air	2.00	2.79	4.00	2.00	2.88	4.00	1.00	1.82	3.00	2.00	3.65	5.00	2.00	3.65	4.00	1.00	2.74	5.00
Noise pollution	1.00	2.47	3.00	1.00	1.82	3.00	0.00	0.00	2.00	1.00	1.82	3.00	2.00	1.82	4.00	0.00	0.00	3.00
Land vibration	2.00	3.19	3.00	2.00	1.82	3.00	0.00	0.00	1.00	1.00	1.82	3.00	0.00	1.82	2.00	0.00	0.00	3.00
Domestic employment	2.00	3.19	4.00	2.00	2.88	4.00	1.00	2.47	4.00	1.00	2.42	5.00	2.00	2.42	5.00	2.00	3.54	5.00
Population control policies	1.00	1.82	4.00	1.00	2.88	4.00	1.00	1.82	3.00	2.00	3.19	5.00	2.00	3.19	5.00	2.00	3.74	5.00
Social and cultural development	0.00	0.00	4.00	0.00	2.88	4.00	2.00	2.88	4.00	2.00	3.54	5.00	3.00	3.54	5.00	2.00	3.86	5.00
Instability of the established spaces	1.00	1.82	4.00	1.00	2.88	4.00	1.00	1.82	3.00	2.00	2.88	4.00	1.00	2.88	4.00	1.00	2.74	5.00
Environmental arrangements	1.00	1.82	4.00	1.00	2.88	4.00	2.00	3.19	5.00	1.00	3.31	5.00	2.00	3.31	4.00	2.00	3.19	5.00
Light	2.00	2.67	5.00	2.00	3.54	5.00	0.00	0.00	3.00	2.00	3.74	5.00	2.00	3.74	5.00	0.00	0.00	5.00

TABLE 5. Positive triangular ideal solution ($\tilde{f}_i^*$) and the negative triangular ideal solution ($\tilde{f}_i^0$)

	$\tilde{f}_i^*$			$\tilde{f}_i^0$		
	l^*	m^*	u^*	l^0	m^0	u^0
Changing the usage of the area	0.00	0.00	3.00	2.00	3.65	5.00
Exposition of the area	0.00	0.00	4.00	2.00	3.19	5.00
Interference with surface water	0.00	0.00	1.00	2.00	3.19	5.00
Interference with ground water	0.00	0.00	1.00	2.00	2.67	4.00
Increasing the traffic of the area	0.00	0.00	3.00	2.00	2.88	5.00
Dust emission	0.00	0.00	3.00	2.00	3.82	6.00
Toxic pollutants and substance emissions to air	0.00	0.00	3.00	2.00	3.65	5.00
Noise pollution	0.00	0.00	1.00	2.00	2.47	4.00
Land vibration	0.00	0.00	1.00	2.00	3.19	4.00
Domestic employment	2.00	3.54	5.00	0.00	0.00	3.00
Population control policies	3.00	3.91	5.00	0.00	0.00	2.00
Social and cultural development	3.00	3.86	5.00	0.00	0.00	3.00
Instability of the established spaces	0.00	0.00	1.00	2.00	2.88	5.00
Environmental arrangements	2.00	3.31	5.00	1.00	1.82	4.00
Light	0.00	0.00	1.00	2.00	3.74	5.00

TABLE 6. Normalized decision matrix

	Air quality			Quietness			Ecology			Surface water			Underground water			Area usage		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
Changing the usage of the area	-0.60	0.00	0.80	-0.60	0.00	0.60	-0.40	0.55	1.00	-0.40	0.47	1.00	-0.40	0.49	0.80	-0.40	0.42	0.80
Exposition of the area	-0.80	0.00	0.80	-0.60	0.42	0.80	-0.60	0.55	1.00	-0.40	0.62	1.00	-0.60	0.42	0.80	-0.60	0.48	0.80
Interference with surface water	-0.20	0.00	0.20	-0.20	0.00	0.20	0.00	0.49	0.80	0.00	0.49	0.80	0.20	0.64	1.00	0.00	0.42	0.80
Interference with ground water	-0.25	0.00	0.50	-0.25	0.00	0.25	0.00	0.57	1.00	0.00	0.53	1.00	0.25	0.67	1.00	0.00	0.62	1.00
Increasing the traffic of the area	-0.40	0.53	1.00	-0.40	0.55	1.00	-0.40	0.46	0.80	-0.60	0.00	0.60	-0.60	0.00	0.80	-0.20	0.58	0.80
Dust emission	-0.17	0.64	1.00	-0.50	0.00	0.67	-0.17	0.64	1.00	-0.17	0.48	0.67	-0.33	0.30	0.50	-0.33	0.30	0.50
Toxic pollutants and substance emissions to air	-0.40	0.61	1.00	-0.60	0.00	0.80	-0.20	0.66	1.00	-0.40	0.49	0.80	-0.40	0.49	0.80	-0.40	0.49	0.80
Noise pollution	-0.25	0.00	0.75	0.00	0.62	1.00	0.00	0.45	0.75	-0.25	0.00	0.25	-0.25	0.00	0.25	0.00	0.62	1.00
Land vibration	-0.25	0.00	0.25	0.00	0.53	1.00	-0.25	0.00	0.25	-0.25	0.00	0.25	-0.25	0.00	0.25	0.00	0.45	0.75
Domestic employment	-0.40	0.71	1.00	-0.20	0.71	1.00	-0.40	0.28	0.80	-0.20	0.34	0.80	-0.20	0.34	0.80	-0.20	0.34	0.80
Population control policies	-0.20	0.78	1.00	-0.20	0.36	0.80	-0.20	0.29	0.80	0.20	0.78	1.00	-0.20	0.78	1.00	-0.40	0.00	0.40
Social and cultural development	-0.20	0.35	0.80	0.00	0.41	0.80	-0.20	0.35	0.80	0.00	0.41	0.80	0.00	0.41	0.80	-0.20	0.20	0.60
Instability of the established spaces	-0.20	0.00	0.20	-0.20	0.00	0.20	0.00	0.55	1.00	-0.20	0.00	0.20	-0.20	0.00	0.20	0.20	0.58	0.80
Environmental arrangements	-0.75	0.14	1.00	-0.50	0.21	1.00	-0.75	0.03	0.75	-0.75	0.03	0.75	-0.50	0.30	1.00	-0.50	0.30	1.00
Light	-0.20	0.00	0.20	-0.20	0.00	0.80	-0.20	0.00	0.80	-0.20	0.00	0.60	-0.20	0.00	0.80	0.00	0.36	0.60

TABLE 6. Continued

	Surface constructions			Area landscape			Soil of the area			Human health and immunity			Social issues			Economic issues		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
Changing the usage of the area	-0.40	0.36	0.80	-0.40	0.49	0.80	-0.40	0.42	0.80	-0.20	0.73	1.00	-0.20	0.73	1.00	-0.40	0.55	1.00
Exposition of the area	-0.40	0.64	0.80	-0.40	0.48	0.80	-0.40	0.58	0.80	-0.40	0.62	1.00	-0.60	0.62	1.00	-0.60	0.42	0.80
Interference with surface water	0.00	0.36	0.60	0.00	0.35	0.60	0.00	0.36	0.60	0.00	0.49	0.80	0.00	0.49	0.80	-0.20	0.00	0.60
Interference with ground water	0.00	0.45	0.75	0.00	0.45	0.75	0.00	0.43	0.75	0.00	0.53	1.00	-0.25	0.53	0.75	0.00	0.45	0.75
Increasing the traffic of the area	-0.60	0.00	0.60	-0.60	0.36	0.60	-0.40	0.36	0.60	-0.40	0.49	0.80	-0.20	0.49	0.80	-0.40	0.42	0.80

Dust emission	-0.33	0.41	0.50	-0.33	0.30	0.50	-0.33	0.30	0.50	-0.17	0.61	0.83	-0.33	0.61	0.67	-0.33	0.35	0.67
Toxic pollutants and substance emissions to air	-0.20	0.56	0.80	-0.20	0.58	0.80	-0.40	0.36	0.60	-0.20	0.73	1.00	-0.20	0.73	0.80	-0.40	0.55	1.00
Noise pollution	0.00	0.62	0.75	0.00	0.45	0.75	-0.25	0.00	0.50	0.00	0.45	0.75	0.25	0.45	1.00	-0.25	0.00	0.75
Land vibration	0.25	0.80	0.75	0.25	0.45	0.75	-0.25	0.00	0.25	0.00	0.45	0.75	-0.25	0.45	0.50	-0.25	0.00	0.75
Domestic employment	-0.40	0.07	0.60	-0.40	0.13	0.60	-0.40	0.21	0.80	-0.60	0.22	0.80	-0.60	0.22	0.60	-0.60	0.00	0.60
Population control policies	-0.20	0.42	0.80	-0.20	0.21	0.80	0.00	0.42	0.80	-0.40	0.14	0.60	-0.40	0.14	0.60	-0.40	0.03	0.60
Social and cultural development	-0.20	0.77	1.00	-0.20	0.20	1.00	-0.20	0.20	0.60	-0.40	0.07	0.60	-0.40	0.07	0.40	-0.40	0.00	0.60
Instability of the established spaces	0.00	0.36	0.80	0.00	0.58	0.80	0.00	0.36	0.60	0.20	0.58	0.80	0.00	0.58	0.80	0.00	0.55	1.00
Environmental arrangements	-0.50	0.37	1.00	-0.50	0.11	1.00	-0.75	0.03	0.75	-0.75	0.00	1.00	-0.50	0.00	0.75	-0.75	0.03	0.75
Light	0.20	0.53	1.00	0.20	0.71	1.00	-0.20	0.00	0.60	0.20	0.75	1.00	0.20	0.75	1.00	-0.20	0.00	1.00

TABLE 7. Calculated entropy measure, divergence values and objective weights of IFs

	e_j			div_j			w_j		
	l	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**
Changing the usage of the area	0.69	0.75	0.88	0.31	0.25	0.12	0.066	0.054	0.037
Exposition of the area	0.89	0.88	0.88	0.11	0.12	0.12	0.023	0.027	0.036
Interference with surface water	0.60	0.63	0.72	0.40	0.37	0.28	0.085	0.081	0.088
Interference with ground water	0.61	0.67	0.71	0.39	0.33	0.29	0.081	0.073	0.089
Increasing the traffic of the area	0.62	0.68	0.82	0.38	0.32	0.18	0.079	0.07	0.057
Dust emission	0.86	0.87	0.83	0.14	0.13	0.17	0.03	0.028	0.052
Toxic pollutants and substance emissions to air	0.89	0.91	0.87	0.11	0.09	0.13	0.023	0.019	0.04
Noise pollution	0.47	0.46	0.65	0.53	0.54	0.35	0.112	0.119	0.107
Land vibration	0.39	0.39	0.54	0.61	0.61	0.46	0.129	0.134	0.143
Domestic employment	0.75	0.73	0.82	0.25	0.27	0.18	0.052	0.06	0.054
Population control policies	0.71	0.70	0.84	0.29	0.30	0.16	0.06	0.066	0.048
Social and cultural development	0.89	0.90	0.83	0.11	0.10	0.17	0.022	0.022	0.051
Instability of the established spaces	0.53	0.57	0.67	0.47	0.43	0.33	0.099	0.096	0.103
Environmental arrangements	0.98	0.97	0.90	0.02	0.03	0.10	0.004	0.006	0.029
Light	0.39	0.37	0.81	0.61	0.63	0.19	0.128	0.138	0.058

TABEL 8. The values of S, R and Q for all ECs

	S	R	Q
Air quality	0.16	0.05	-0.05
Quietness	0.26	0.07	0.13
Ecology	0.32	0.05	0.18
Surface water	0.21	0.05	0.04
Underground water	0.23	0.05	0.06
Area usage	0.39	0.07	0.31
Surface constructions	0.40	0.09	0.34
Area landscape	0.39	0.08	0.32
Soil of the area	0.21	0.03	0.00
Human health and immunity	0.44	0.09	0.37
Social issues	0.41	0.09	0.36
Economic issues	0.22	0.05	0.01

TABLE 9. The ranking of the ECs by S, R and Q in descending order

	By S	By R	By Q
Air quality	1	2	1
Quietness	6	8	6
Ecology	7	4	7
Surface water	3	3	4
Underground water	5	6	5
Area usage	9	7	8
Surface constructions	10	12	10
Area landscape	8	9	9
Soil of the area	2	1	2
Human health and immunity	12	10	12
Social issues	11	11	11
Economic issues	4	5	3

Based on the results of the last studies the surface infrastructures and economic problems have the least importance in Boog mine environmental effects. The quantitative matrix method was used for the EIA. Air quality, human health and safety and ecology have been effected more than the other parameters with 33.63, 28. 26 and 28.09%, respectively. Considering the accomplished calculations and considering that the environmental parameters is bigger than human parameter, the present project has been evaluated by using Philips mathematical model as a sustainable case; but the sustainability has been located in weak class [39].

5. CONCLUSION

Mining activities are kind of industries with long-term environmental effects. Environmental- impact-assessment (EIA) of mines is important for environmental problems monitoring. Obtaining the optimized alternative with the highest degree of efficiency for all of the relevant attributes is the object of MADM. VIKOR method has been widely used in various domains of decision-making because of its preferences.

The developed Fuzzy- VIKOR method is proposed to study how the mining activities of granite quarry Boog affect the environment. By using the presented method, the uncertainties of decision-makers opinions were expressed numerically. Objective weights are determined based on Shannon entropy for criteria weighting of the impacting factors. The Fuzzy- VIKOR is applied to assess the environmental components priorities. The final response of the Fuzzy- VIKOR method showed that five components of “Air quality” = “Soil of the region” were the most considerable components in the field of interest. The proposed systematic method is very flexible and enables us to assess and rank environmental components (ECs).

6. REFERENCES

1. Saffari, A., Ataei, M., Sereshki, F., Naderi, M. “Environmental impact assessment (EIA) by using the Fuzzy Delphi Folchi (FDF) method (case study: Shahrood cement plant, Iran)” ***Environment, Development and Sustainability*** Vol. 21, (2017), 817-860. DOI: 10.1007/s10668-017-0063-1
2. Kakha, G. H., Tabasi, S., Jami, M., Danesh Narooei, Kh. “Evaluation of the Impacting Factors on Sustainable Mining Development, Using the Grey-Decision Making Trial and Evaluation Laboratory Approach.” ***International Journal of Engineering, Transactions A: Basics,*** Vol. 32, No. 10, (2019), 1497-1505. DOI: 10.5829/ije.2019.32.10a.20
3. Owen, J.R., Kemp, D., Extractive Relations: Countervailing Power and the Global Mining Industry. Sheffield, UK. 2017.
4. Dubiński, J. “Sustainable development of mining mineral resources.” ***Journal of Sustainable Mining,*** Vol. 12, No. 1, (2013), 1-6. DOI: 10.7424/jsm130102
5. Farjana, S. H., Huda, N., Mahmud, M.A. P., Saidur, R. “A review on the impact of mining and mineral processing industries through life cycle assessment” ***Journal of Cleaner Production*** Vol. 231, (2019), 1200-1217. DOI:10.1016/j.jclepro.2019.05.264
6. Kaya, T., Kahraman C. “An integrated fuzzy AHP-ELECTRE methodology for environmental impact assessment.” ***Expert Systems with Applications,*** Vol. 38, No. 7, (2011), 8553-8562, DOI:10.1016/j.eswa.2011.01.057
7. da Silva Dias, A.M., Fonseca, A., Paglia, A.P. “Technical quality of fauna monitoring programs in the environmental impact assessments of large mining projects in southeastern Brazil.” ***Science of the Total Environment,*** Vol. 650, (2019), 216-223. DOI:10.1016/j.scitotenv.2018.08.425

8. Glasson, J., Therivel, R., Chadwick, A. Introduction to Environmental Impact Assessment, 3rd Edition, Routledge, London and New York, 2005.
9. Morris, P., Therivel, R. Methods of Environmental Impact Assessment, Taylor & Francis, 2001.
10. Leopold, L.B., Clarke, F.E., Hanshaw, B.B. A Procedure for Evaluating Environmental Impact. United States Department of the Interior, Washington, DC, 1971.
11. Josimovic, B., Petric, J., Milijic, S. "The use of the Leopold matrix in carrying out the EIA for wind farms in Serbia." ***Energy and Environment Research***, Vol. 4, No. 1, (2014), 43. DOI: 10.5539/eer.v4n1p43
12. Pastakia, C. M. R. The rapid impact assessment matrix (RIAM)—a new tool for environmental impact assessment. In Environmental impact assessment using the rapid impact assessment matrix (RIAM), K. Jensen; Fredensborg: Olsen & Olsen, 1998.
13. Pastakia, C. M. R., Jensen, A. "The rapid impact assessment matrix (RIAM) for EIA." ***Environmental Impact Assessment Review***, Vol. 18, (1998), 461-482. DOI: 10.1016/S0195-9255(98)00018-3
14. Phillips, J. "Evaluating the level and nature of sustainable development for a geothermal power plant." ***Renewable and Sustainable Energy Reviews***, Vol. 14, No. 8, (2010), 2414-2425. DOI: 10.1016/j.rser.2010.05.009
15. Folchi, D. I. R. "Environmental impact statement for mining with explosives: A quantitative method", in 29th Annual Conference on Explosives and Blasting Technique, Nashville, Tennessee, USA, (2003).
16. Mohebalia, S., Maghsoudy, S., Doulati Ardejani, F. "Application of data envelopment analysis in environmental impact assessment of a coal washing plant: A new sustainable approach" ***Environmental Impact Assessment Review***, Vol. 83, (2020), 106389. DOI: 10.1016/j.eiar.2020.106389
17. Wang, N., Wei, D. "A modified D numbers methodology for environmental impact assessment" ***Technological and Economic Development of Economy,*** Vol. 24, (2018), 653-669. DOI: 10.3846/20294913.2016.1216018
18. Parkin, J. "A philosophy for multiattribute evaluation in environmental impact assessments" ***Geoforum***, 1992, 23, 467-475. DOI: 10.1016/0016-7185(92)90003-M
19. Zhao, H. X., Zhang, X. Q. "Building index system of tourism environmental impact assessment in the Desert Park based on intuitionistic fuzzy multiple attribute decision making method" ***Issues of Forestry Economics***, Vol. 37, No. 2, (2017), 55-60.
20. Tseng, M. L., Wu, K. J., Lee, C. H., Lim, K. M., Bui, T. D., Chen, C. C. "Assessing sustainable tourism in Vietnam: a hierarchical structure approach" ***Journal of Cleaner Production***, Vol. 195, (2018), 406-417. DOI: 10.1016/j.jclepro.2018.05.198
21. Shemshadi, A., Shirazi, H., Toreihi, M., Tarokh, M.J. "A fuzzy VIKOR method for supplier selection based on entropy measure for objective weighting" ***Expert Systems with Applications***, Vol. 38, (2011), 12160-12167. DOI: 10.1016/j.eswa.2011.03.027
22. Opricovic, S. Multicriteria Optimization of Civil Engineering Systems. Ph.D. Thesis, Faculty of Civil Engineering, Belgrade, Serbia, 1998.
23. Opricovic, S., Tzeng, G. H. "Multicriteria planning of post-earthquake sustainable reconstruction" ***Computer-Aided Civil and Infrastructure Engineering,*** Vol. 17, No. 3, (2002), 211-220. DOI: 10.1111/1467-8667.00269
24. Opricovic, S., Tzeng, G.H. "Compromise solution by MCDM methods: a comparative analysis of VIKOR and TOPSIS" ***European Journal of Operational Research***, Vol. 156, No. 2, (2004), 445-455. DOI: 10.1016/S0377-2217(03)00020-1
25. Tavakkoli-Moghaddam, R., Heydar, M., Mousavi, S.M. "An integrated AHP-VIKOR methodology for plant location selection" ***International Journal of Engineering, Transactions B: Applications***, Vol. 24, No. 2, (2011), 127- 137.
26. Zeleny, M. Multiple criteria decision making. New York: Mc-Graw-Hill, 1982.
27. Zhu, G.-N., Hu, J., Qi, J., Gu, C. C., Peng, Y. H. "An integrated AHP and VIKOR for design concept evaluation based on rough number" ***Advanced Engineering Informatics***, Vol. 29, (2015), 408-418. DOI: 10.1016/j.aei.2015.01.010
28. Tzeng, G. H., Lin, C. W., Opricovic, S. "Multi-criteria analysis of alternative fuel buses for public transportation" ***Energy Policy***, Vol. 33, (2005), 1373-1383. DOI: 10.1016/j.enpol.2003.12.014
29. Zadeh, L. A. "Fuzzy sets" ***Information Control***, Vol. 8, (1965), 338-353. DOI:10.1016/S0019-9958(65)90241-X
30. Bellman, R. E., Zadeh, L. A. "Decision-making in a fuzzy environment" ***Management Science***, Vol. 17, No. 4, (1970), 141-164. DOI:10.1287/mnsc.17.4.B141
31. Bevilacqua, M., Ciarapica, F., Giacchetta, G. "A fuzzy-QFD approach to supplier selection" ***Journal of Purchasing and Supply Management***, Vol. 12, No. 1, (2006), 14-27. DOI:10.1016/j.pursup.2006.02.001
32. Wang, T. C., Lee, H. D. "Developing a fuzzy TOPSIS approach based on subjective weights and objective weights" ***Expert Systems with Applications***, Vol. 36, (2009), 8980-8985. DOI: 10.1016/j.eswa.2008.11.035
33. Mirauda, D., Ostoich, M. "MIMR Criterion Application: Entropy Approach to Select the Optimal Quality Parameter Set Responsible for River Pollution" ***Sustainability***, Vol. 12, (2020), 2078. DOI: 10.3390/su12052078
34. Lihong, M., Yanping, Z., Zhiwei, Z. "Improved VIKOR algorithm based on AHP and Shannon entropy in the selection of thermal power enterprise's coal suppliers", International conference on information management, innovation management and industrial engineering, (2008).
35. Ataei, M., Tajvidi Asr, E., Khalokakaie, R., Ghanbari, K., Tavakoli Mohammadi, M. R. "Semi-quantitative environmental impact assessment and sustainability level determination of coal mining using a mathematical model" ***Journal of Mining and Environment***, Vol. 7, No. 2, (2016), 185-193. DOI: 10.22044/jme.2016.515
36. Mirmohammadi, M., Gholamnejad, J., Fattahpour, V., Seyedsadri P, Ghorbani Y. "Designing of an environmental assessment algorithm for surface mining projects" ***Journal of Environmental Management***, Vol. 90, (2009), 2422-2435. DOI: 10.1016/j.jenvman.2008.12.007
37. Liu, Y. C., Chen, C. S. "A new approach for application of rock mass classification on rock slope stability assessment" ***Engineering Geology***, Vol. 89, (2007a), 129-143. DOI: 10.1016/j.enggeo.2006.09.017
38. Liu, Y. C., Chen, C. S. "A new approach to classification base on association rule mining" ***Decision Support Systems***, Vol. 42, (2007b), 674-689. DOI: 10.1016/j.dss.2005.03.005
39. Kakha, G. H., Tabasi, S., Docheshmeh Gorgij, A., Jami, M. "Environmental impact assessment and sustainability level determination of Boog Granite Mine using Philips model" ***Journal of Natural Environmental Hazards***, Vol.08, No. 22, (2020), 199-212. DOI: 10.22111/JNEH.2019.28328.1488

Persian Abstract

چکیده

یکی از مهم‌ترین چالش‌های زیست محیطی، فعالیت‌های معدنکاری می‌باشد. اخیراً، حل مساله و رده‌بندی مولفه‌های زیست محیطی (ECs) که تحت تاثیر فعالیت‌های معدنکاری قرار می‌گیرند، به یک فاکتور استراتژیک کلیدی در روند ارزیابی آثار زیست محیطی (EIA) تبدیل شده است. روش ویکور به عنوان یک روش تصمیم‌گیری موثر به منظور ارزیابی اثرات زیست محیطی معدن سنگ گرانیت بوگ واقع در جنوب شرق ایران مورد استفاده قرار گرفته است. روش ویکور بر درجه‌بندی میزان تاثیر هر فاکتور موثر (IF) روی مولفه‌های محیط زیستی تعیین شده، تمرکز دارد. در این پژوهش، یک مدل ارزیابی بر مبنای استفاده از اعداد فازی در فرآیندهای تصمیم‌گیری ارائه شده است که مساله عدم قطعیت و ابهام موجود در ادراک ذهنی و تجربه افراد خبره را حل کرده است. آنتروپی شانون به منظور تعدیل اوزان ذهنی افراد تصمیم‌گیرنده به وزن‌های واقعی مورد استفاده قرار گرفته است. نتایج حاصل از رده‌بندی فاکتورهای R، S و Q بدست آمده است. در این مورد، کیفیت هوا (R= 0.05, S= 0.16, Q= -0.05) به عنوان مهم‌ترین مولفه زیست محیطی که تحت تاثیر آلودگی حاصل از فعالیت‌های معدنکاری قرار گرفته است، تعیین شد. مقایسه نتایج با روش ماتریس استاندارد تایید می‌کند که فاکتور کیفیت هوا به میزان ۳۳/۶۳ درصد بیشتر از سایر پارامترها تحت تاثیر فعالیت‌های معدنکاری قرار گرفته است. روش فازی- ویکور، یک روش سیستماتیک است که به راحتی می‌تواند جهت بررسی های کمی زیست محیطی و سایر مسائل گزینشی مهندسی معدن مورد استفاده قرار گیرد.