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CRITERIA FOR QUALITATIVE ASSESSMENT OF INDICATORS OF THE IMPACT OF PLANNED ACTIVITIES ON THE STATE OF THE ENVIRONMENT

In order to assess the impact of planned activities on the environment of mining enterprises, it is necessary to realize that the impact factors are very diverse in terms of characteristics. Therefore, during the preparation of Environmental Impact Assessment Reports of planned activities, developers are faced with the problem of defining, classifying and quantifying the impact of planned activities on the environment. A qualitative assessment of impacts without reference to an assessment scale is insufficiently informative. In this regard, the authors set a goal to develop a method of comprehensive assessment of the impact of the planned activity of mining enterprises on the environment, where the quantitative measurement of each impact on the environment will be based on the assessment of the environmental consequences of the planned activity according to defined single criteria. The work contains a list of mandatory and additional criteria for the impact of the planned activity on the environment, which should be determined during the development of the Environmental Impact Assessment Report. The types of influence of these criteria are determined and their characteristics are provided. Each of the types of impact is evaluated in points on the scale of ecological danger. A scale for evaluating the total danger of the impact of the planned activity was developed with five degrees of danger: low, moderate, medium, high, extremely high. The results of the study can become the basis for assessing the consequences of the activities of mining enterprises within the framework of conducting a comprehensive environmental assessment of the planned activity, and will also make it possible to make a qualitative scientific forecast of possible environmental changes as a result of the implementation of this or that economic decision.

Key words: *mining activity, mining enterprises, environmental impact assessment, environmental impact assessment criteria.*

Introduction. Environmental impact assessments are effective tools for supporting sustainable development because they allow integrating the goals of the "green economy" into the process of making strategic decisions as well as decisions at the level of individual projects.

In Ukraine, the procedure of environmental impact assessments was introduced at the end of 2017, in particular for the implementation of the EU environmental legislation provided for in the Association Agreement between Ukraine and the EU.

Mandatory elements of the procedure of the environmental impact assessments, produced by almost fifty years of experience in the countries of America and the EU, include, in particular, consideration of alternatives to the planned activity, transparency of the procedure, public participation, including at the early stages, inclusion of mandatory environmental conditions for the implementation of the planned activity in the decision on the consequences of the procedure of the environmental impact assessments, and opportunities for judicial appeal of administrative decisions made as a result of the EIA procedure. In contrast to the conclusion of the state environmental examination, the environmental impact assessment procedure allows the authorized central or territorial body to formulate mandatory environmental conditions for the economic entity for the implementation of the planned activity, which factually become part of the decision that allows it to implement the activity only under the condition of fulfilling the specified conditions [1].

In accordance with the current legislation on environmental impact assessment, this procedure is carried out for projects that have a significant impact on the environment in various areas, including the mining industry.

Qualitative impact assessments that do not reference an assessment scale lack sufficient information. Therefore, the authors aimed to develop a method for integrated assessment of the environmental impact of planned mining activities. This method will use unified criteria to quantitatively measure each environmental impact based on the assessment of environmental consequences of planned activities.

Emergence of prerequisites for the problem and formulation of the problem. Research by scientists in the fields of ecology and environmental protection has led to the conclusion that the greater the ecological consequences of anthropogenic activity, the earlier they should be prevented. Today, there is a need not so much for

effective measures to eliminate negative consequences as for reliable mechanisms for their prevention. Even before the implementation of the planned activity, it is necessary to investigate possible changes in the environment that may have adverse consequences. Nevertheless, it was not enough to make a qualitative scientific forecast of possible changes in the environment as a result of the implementation of this or that economic decision. It is important that the conclusions of such a forecast be included in the content of the decision before its adoption and implementation to ensure its environmental safety for society.

Analysis of existing problems. For the mining industry, international and European legislation stipulates that an environmental impact assessment is required for projects to extract hydrocarbons and other minerals, including those mined in quarries. The type of economic activity of mineral extraction is subject to the Law of Ukraine "On Environmental Impact Assessment" 2059-VIII dated May 23, 2017. Reasoned expert environmental impact assessment is both a norm of the current Ukrainian legislation and a necessary condition for achieving a balanced development of economic activity in combination with natural and social environments.

According to the analysis of the legal requirements for environmental impact assessments and the current practice of their implementation, the procedure for environmental impact assessments consists of six steps, which can be completed in about six months in total (before receiving the conclusion on the environmental impact assessment or a refusal to issue the conclusion). At the same time, some problematic points have been identified in the implementation of the environmental impact assessments, whose solution will increase their effectiveness [2]. It should be noted that in order to assess the impact of the planned activity on the environment, it is necessary to realize that the factors of influence are very diverse in terms of characteristics. Therefore, during the execution of work on the preparation of the environmental impact assessment reports of the planned activity, the developers are faced with the problem of defining, classifying, and quantifying the impact of the planned activity on the environment.

Determining the impact on the environment. The purpose of determining the environmental impacts of a mining facility or complex is to identify all possible impacts caused by: execution of preparatory and construction works and implementation of planned activities; use of natural resources in the process of carrying out the planned activity; emissions and discharges of pollutants, noise, vibration, light, heat and radiation pollution, radiation and other impact factors, as well as the implementation of operations in the field of waste management; risks to the health of people, objects of cultural heritage, including due to the possibility of emergency situations; by the cumulative impact of other existing facilities, planned activities, and facilities for which a decision has been made to carry out the planned activity, taking into account all existing environmental problems related to territories of special environmental importance, which may be affected or which natural resources can be used; the impact of the planned activity on the climate, including the nature and scale of greenhouse gas emissions, and the sensitivity of the activity to climate change; technology and substances used.

The conduct of the environmental impact assessments is a systematic, substantiated assessment of the environmental aspects of the planned activity. This is especially important when these aspects of the project require the implementation of special procedures and actions, for example, those related to the safety of people and working conditions. At the same time, it is necessary to consider the technological part of the project proposals and the main principles regarding the expected impact on the environment.

Such principles include:

– environmental situation in the territory of the intended location of the mining enterprise (production, workshop, site, etc.);

– public opinion regarding the types of economic activity carried out in this territory;

– the presence of impacts that cannot be avoided with existing technologies;

– the probability of the impact spreading to other administrative territories.

They also substantiate the goals and terms of implementation of project proposals and the location of the future enterprise. The latter is especially important with regard to the nature of the objects of influence (socio-demographic structure of the local population, diversity of flora and fauna, etc.) and the limits of further research on the environmental impact assessments.

Thus, the stage of determining environmental impacts involves a fairly complete analysis of the technological, economic, social, and environmental aspects of the planned activity.

Criteria for the impact of planned activities on the environment. Based on the development of the Law of Ukraine "On Environmental Impact Assessment" 2059-VIII dated May 23, 2017 [3], regulatory documents, and reports on the Environmental Protection Agency, a list of criteria for the impact of planned activities on the environment was compiled (table 1).

Explaining the information given in Table 1, the following can be added:

The scale of influence depending on the size of the territory over which they spread can be:

– local (local, object) – cover small territories, industrial districts, city districts or individual cities;

– regional – cover administrative-territorial units or natural zones;

– national (state) – cover a separate country;

– cross-border – go beyond the borders of one country.

The probability of impact is a statistical value:

– if the probability of a negative effect is close to 1, then the effect will occur, it is reliable. For example, noise and vibration from vehicles during construction work is a reliable impact;

– if the probability of the occurrence of a negative effect approaches 0, then the effect may not occur, it all depends on additional conditions – the effect is unreliable. For

Table 1. Criteria for the impact of planned activities on the environment
Таблиця 1. Критерії впливу планованої діяльності на навколишнє середовище

№	Criteria	Characteristic	Type of influence
Mandatory criteria for determination (according to the LoU "On Environmental Impact Assessment")			
1	Scale of influence	characterizes the area of the territory and the population that will be affected by the planned activity	local (local, object), regional, national (state), cross-border
2	Intensity of influence	characterizes the degree of anthropogenic impact on the environment during the planned activity (*magnitude of impact per unit of time*)	significant (strong), moderate, insignificant (weak)
3	Probability of impact	characterizes the likelihood of impact during the planned activity	reliable, unreliable
4	Duration of impact	characterizes the time span of exposure or characterizes the time of exposure	short-term (temporary), medium-term (temporary), long-term (temporary, permanent)
5	Frequency of impact	characterizes the repeatability of the impact over time	one-time, regular (permanent)
6	Nature of influence	a complex characteristic based on the generalization of all the information collected above	admissible (*acceptable*), conditionally admissible (subject to compliance with additional conditions) (*conditionally acceptable*), inadmissible (*unacceptable*)
			positive, negative
Additional criteria (optional for definition)			
7	Possibility of elimination	characterizes the possibility of excluding a negative impact due to the adoption of additional environmental protection, technological or other measures	those that can be corrected (the consequences of which can be eliminated); those that cannot be corrected (the consequences of which cannot be eliminated)
8	Method of influence	characterizes how the planned activity affects the objects of the environment: directly on the object, or through the influence on other objects of the environment	direct (direct, contact), mediated (non-contact, indirect)
9	Origin of influence	characterizes the source of influence	primary (related to the direct impact of activities on environmental objects), secondary (are the consequences of primary changes in the environment or environmental objects)
10	Possibility of accumulation of consequences	characterizes the possibility of accumulation of several negative effects	cumulative (consequences that can reinforce each other and grow progressively); non-cumulative (influences that do not tend to accumulate and influence each other in any way)
11	The risk of emergency situations	characterizes the probability of occurrence of emergency situations	low (*acceptable*); moderate (*conditionally acceptable*); high (*unacceptable*)
12	The degree of danger of the planned activity	determined according to the current classifier of hazardous industries and enterprises	moderate; increased

example, the impact on the fertile layer during construction or reconstruction on an already existing industrial site is unreliable, because the fertile soil layer is usually absent on industrial sites.

The duration of exposure is distinguished by the time of exposure to the environment:

– permanent, which will accompany the activity throughout its life cycle, for example, the impact on the geological environment during the extraction of a mineral occurs throughout the entire life of the quarry;

– temporary (short- and medium-term), affecting the environment for a small period. For example, dust emissions into the air during the dismantling of structures at an industrial site during its reconstruction.

The frequency of exposure is divided into one-time, for example, emissions into the air during the removal of the soil-vegetation layer during preparatory work during the development of minerals; or regular (permanent) – emissions into the air of polluting substances formed in technological processes at the industrial site.

According to the possibility of elimination, impacts on the environment can be divided into those that can be corrected (the consequences of which can be eliminated) and those that are not corrected (the consequences of which cannot be eliminated). The first can be attributed to the restoration of the soil-vegetation layer with the help of reclamation on spent quarries or dumps. Changes in climatic conditions, the death of ecosystems,

and the fatal nature of environmental changes that cannot restore the natural balance are among the impacts that cannot be corrected. Activities that are characterized by such irreparable consequences necessarily require the development of measures to reduce the negative impact.

The planned activity can affect the environment directly (change of the landscape during the development of minerals, reduction of the area of agricultural plots due to the construction of new industrial enterprises or sites, impoverishment of flora and fauna of water bodies due to pollution of the river basin by production discharges) and indirectly (change in the level of groundwater during mining of minerals, an increase in the general morbidity of the population in the zone of influence of industrial site emissions, soil pollution through the air with emissions of pollutants or through atmospheric precipitation).

By origin, the impact can be primary, that is, directly related to the impact of the planned activity on the environment (air pollution during the construction and operation of metallurgical enterprises, pollution of water bodies by wastewater discharges) and secondary, which are the consequences of primary changes in the environment or environmental objects (increase in broncho-pulmonary diseases among the population as a result of atmospheric pollution by metallurgical enterprises; secondary pollution of water bodies in case of disturbance of silt that has accumulated pollution from the water body).

According to the possibility of accumulation, they affect the environment by allocation into accumulative (consequences that have the ability to strengthen each other and grow progressively) and non-accumulating (influences that do not tend to accumulate and in any way affect each other). Cumulative impacts include emissions of pollutants into the atmosphere from industrial enterprises located near one, or emissions of substances that have a summation or potentiation effect. Non-accumulated impacts, for example, machinery noise during construction; siltation of the river during its clearing and deepening works.

The risk of emergency situations characterizes the probability of a certain negative event occurring at a certain time or under certain circumstances on the territory of the object of the planned activity.

Such a risk can be calculated similarly to the well-known formula for the generalized risk calculation [4]:

$$R = N_{avg.} / N_{gen.} \quad (1)$$

where R – risk (in our case – the risk of emergency situations);

$N_{avg.}$ – the statistically recorded number of adverse events (in our case, the number of accidents at similar facilities that occurred during a certain period of time (for example, a year));

$N_{gen.}$ – the total, theoretical number of phenomena (in our case, the total number of similar objects in the country).

When calculating acceptable risk, it is assumed that safety is not the absolute absence of danger, but the absence of unacceptable risk. Acceptable risk is a risk that does not exceed the maximum permissible level (MRL) on the territory of the object of the planned activity and beyond it; unacceptable – exceeds the MRL. There is a problem of establishing the level of acceptable risk [5].

The quantitative indicator of accident risk is shown in Table 2. We believe that the indicator of accident risk can be determined on a scale similar to the scale of social risk assessment according to SBR A.2.2.-1-2003 "Composition and content of environmental impact assessment materials (EIAM) during design and construction of enterprises, houses and structures": high (unacceptable) $R \geq 10^{-3}$; moderate (conditionally acceptable) $10^{-6} < R < 10^{-3}$; low (acceptable) $R \leq 10^{-6}$, or according to the scales according to the materials of scientific works [6].

Table 2. Classification of levels of risk of environmental impact
Таблиця 2. Класифікація рівнів ризику впливу на довкілля

Level	Quantitative indicator
Classification of levels of the probabilistic component of environmental risk [4]	
Unacceptable	$>10^{-6}$
Conditionally acceptable	$10^{-6} – 10^{-7}$
Acceptable	$10^{-7} – 10^{-8}$
Absolutely acceptable	$< 10^{-8}$
Levels of acceptable risk in economically developed countries [3, 5]	
minimal	$\leq 10^{-8}$
maximum permissible	$<10^{-5}$
According to [5,6], in practical activity, a risk that is less or equal to the minimum is considered absolutely acceptable; a risk whose value exceeds the permissible limit is considered absolutely unacceptable.	

The degree of danger of the planned activity can be determined according to the current classifier of dangerous industries and enterprises and be moderate or elevated. An object has an increased level of danger if it meets the requirements of the Law of Ukraine "On Objects of Increased Danger" [7]. If a potentially dangerous object is not covered by the above-mentioned documents, then its level of danger is considered moderate [8].

Assessing the intensity of the impact and the nature of the impact is a difficult task for the experts compiling the report, as there is currently no generally accepted method or scale for their quantitative measurement. Specialists can determine only on the basis of personal experience and knowledge whether the intensity of the impact will be significant (strong), moderate or insignificant (weak). Similarly, the method of expert assessments determines a complex characteristic - the nature of the impact: admissible (*acceptable*), conditionally permissible (*conditionally acceptable*), unacceptable (*unacceptable*), positive or negative.

Qualitative assessment of impacts without reference to an assessment scale is not informative enough, therefore it is necessary to develop a methodology for comprehensive assessment of criteria for the impact of planned activities on the environment, where the quantitative measurement of each impact on the environment will be based on an assessment of the severity of the environmental consequences of the planned activity.

Only a thorough study of an already operating object can realistically assess the level of activity impact. Impact assessment using known methods requires calculations based on monitoring data, literary sources, regulatory documents or experimental studies. But at the stage of assessing the impact of the planned activity, such data is not available, but they can be obtained using the method of expert assessments. Therefore, when working on the issue of the development of methodological bases for the identification (assessment) of ecological impacts on the environment during the implementation of EIA, the task was set to adapt the method of expert assessments for the qualitative assessment of the indicators of the impact of the planned activity in order to determine the level of its danger and choose the safest alternatives.

For the procedure of assessing the impact on the environment, it is proposed to develop an assessment scale of impacts - a special case of the order scale, which

Table 3. Impact of the planned activity on the environment
Таблиця 3. Вплив планованої діяльності на навколишнє середовище

№	Criteria	Type of influence	Danger scale score
Mandatory criteria for determination (according to the LoU "On Environmental Impact Assessment")			
1	Scale of influence	local (local. Object)	1
		regional	2
		national (state)	3
		cross-border	4
2	Intensity of influence	insignificant (weak)	1
		moderate	2
		significant (strong)	3
3	Probability of influence	unreliable	0
		reliable	1
4	Duration of influence	short-term (temporary)	1
		middle-term (temporary)	2
		long-term (permanent)	3
5	Frequency of influence	one-time	0
		regular (permanent)	1
6	Nature of influence	admissible (*acceptable*)	0
		conditionally admissible (subject to compliance with additional conditions) (*conditionally accepted*)	1
		inadmissible *(unacceptable)*	2
		positive	0
		negative	1
Total minimum possible value of points according to mandatory criteria			3
Total maximum possible value of points according to mandatory criteria			14
Additional criteria (optional for definition)			
7	Possibility of elimination	those that can be corrected (the consequences of which can be eliminated)	0
		those that cannot be corrected (the consequences of which cannot be eliminated)	1
8	Method of influence	mediated (non-contact, indirect)	1
		direct (direct, contact)	1
9	Origin of influence	primary (related to the direct impact of activities on environmental objects)	2
		secondary (are the consequences of primary changes in the environment or environmental objects)	1
10	Possibility of accumulation of consequences	cumulative (consequences that can reinforce each other and grow progressively)	1
		non-cumulative (influences that do not tend to accumulate and influence each other in any way)	2
11	The risk of emergency situations The risk of emergency situations	low (*acceptable*)	1
		moderate *(conditionally acceptable)*	2
		high *(unacceptable*)	3
12	The degree of danger of the planned activity	moderate	1
		increased	2
Total minimum possible value of points according to additional criteria			5
Total maximum possible value of points according to additional criteria			11
Total minimum possible value of points for all criteria (mandatory+additional)			8
Total maximum possible value of points for all criteria (mandatory+additional)			25

would include a set of basic criteria characterizing the impact of the object on human health and the surrounding natural environment by analogy with studies [9, 10]. Based on the analysis of regulatory documentation and literary sources, six mandatory criteria and six additional (optional) criteria were selected (see table 1). Next, it is proposed to evaluate the weight of each of the criteria by the method of expert evaluations, which is often used in ecology to analyze the risks of chemical-technological projects or to choose one of the options of technical devices from several.

Next, each of the types of impact given in Table 1 was evaluated in terms of points on the danger scale. Then table 1 can be presented in the following form (table 3).

Thus, if we sum up the points in table 3, then the total minimum possible value of the points according to the mandatory criteria will be equal to 3 points. The total maximum possible value of points according to mandatory criteria will be equal to 14 points. By analogy with the risk rating scale according to [11], we suggest using a 15-point scale of the danger of the impact of the planned activity with five gradations: from 0 to 3 points – low danger; from 4 to 6 – moderate; from 7 to 9 – medium; from 10 to 12 – high; from 13 to 15 is extremely high.

The total minimum possible value of points for all criteria (mandatory + additional) will be equal to 8 points. The total maximum possible value of points for all criteria (mandatory + additional) will be equal to 25 points. In the case of evaluating both mandatory and additional criteria, we suggest using a 25-point scale for assessing the danger of the impact of the planned activity with five gradations: from 0 to 5 points – low danger; from 6 to 10 – moderate; from 11 to 15 – medium; from 16 to 20 – high; from 21 to 25 is extremely high.

In the opinion of the authors, it is advisable to determine the degree of danger either by only 6 mandatory criteria (express analysis) or by all 12 criteria (full, in-depth analysis).

Conclusions

A comprehensive assessment of the impact of a mining enterprise on the environment with the criteria of environmental safety, social responsibility and economic efficiency is a tool for ensuring the sustainable development of the industry. The results of a comprehensive assessment can determine the main problems of ensuring environmental safety, social responsibility and economic efficiency. The proposed scale for assessing the total risk of impact on the environment is a quantitative and unambiguous indicator of the quality of the object under investigation and can be used as a criterion during the development of the Report on the assessment of the impact on the environment of the planned activity of the mining enterprise.

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КРИТЕРІЇ ЯКІСНОЇ ОЦІНКИ ПОКАЗНИКІВ ВПЛИВУ ЗАПЛАНОВАНОЇ ДІЯЛЬНОСТІ НА СТАН НАВКОЛИШНЬОГО СЕРЕДОВИЩА

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Для того щоб оцінити вплив запланованої діяльності на навколишнє середовище гірничих підприємств, потрібно усвідомлювати, що фактори впливу дуже різноманітні за характеристиками. Тому під час підготовки звітів з оцінки впливу на довкілля плановaної діяльності розробники стикаються з проблемою визначення, класифікації та кількісної оцінки впливу плановaної діяльності на довкілля. Якісна оцінка впливів без прив'язки до шкали оцінки є недостатньо інформативною. У зв'язку із цим автори поставили за мету розробити методику комплексної оцінки впливу плановaної діяльності гірничих підприємств на навколишнє середовище, де кількісний вимір кожного впливу на навколишнє середовище базуватиметься на оцінці екологічних наслідків запланованої діяльності за визначеними єдиними критеріями. У роботі складено перелік обов'язкових і додаткових критеріїв впливу плановaної діяльності на навколишнє середовище, що доцільно визначати під час розробки звіту з оцінки впливу на довкілля. Визначено види впливу цих критеріїв та надано їх характеристику. Кожен із видів впливу оцінено в балах за шкалою екологічної небезпеки. Розроблено шкалу оцінювання сумарної небезпеки впливу плановaної діяльності з п'ятьма градаціями небезпеки: низька, помірна, середня, висока, надзвичайно висока. Результати дослідження можуть стати основою для оцінки наслідків діяльності гірничих підприємств у рамках проведення комплексної екологічної оцінки плановaної діяльності, а також дадуть змогу зробити якісний науковий прогноз можливих змін довкілля внаслідок реалізації того чи іншого господарського рішення.

Ключові слова: *видобувна діяльність, гірничі підприємства, оцінка впливу на довкілля, критерії оцінки впливу на довкілля.*