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MATHEMATICAL MODEL FOR SELECTING PRIORITIES FOR INDICATORS OF THE MONITORING SYSTEM OF TECHNOGENIC, NATURAL AND ENVIRONMENTAL FACTORS

Software and hardware means of the automated system for monitoring environmental parameters in the zone of influence of potentially dangerous industrial facilities, which are a source of dangerous factors affecting the environment and human society, need a mathematical apparatus for the analysis and justification of the level of priorities in the program for monitoring dangerous factors and indicators of environmental environmental conditions. This mathematical model plays an important role in determining the order and sequence of collection and analysis of data on the quality of air, water, soil and other aspects of the environment for an automated system. Such automated systems of environmental monitoring allow not only to obtain information about pollution levels, chemical composition, meteorological conditions and other environmental indicators, but also to form corrective effects in the system of automated management of the state of the environment. This provides an opportunity to assess the quality of the environment, carry out functional zoning of the monitoring area and take corrective measures to reduce the impact of pollution and improve the ecological state of the environment.

The article is devoted to mathematical modeling and a systematic approach to determining priorities for the development of a system of adaptive monitoring of man-made, natural environmental factors of industrial enterprises. Features of the formation of an interval scale for indices and indicators of ecosystem disturbances under the influence of industrial load are given. The peculiarity of the formation of this article is the substantiation of the approach to the ranking of priorities based on the expert-analytical assessment of threats from man-made loads on the territory of the industrial enterprise based on the quantitative assessment of indicators of ecosystem violations. The developed model can be presented in the form of a comprehensive procedure for the formation of recommendations to managers and individuals, which will allow to objectively evaluate the options for supporting management decisions, analyze the possible results of their implementation, and reasonably choose the optimal solution for improving the environmental monitoring system at the enterprise.

Key words: *model, labor safety, interval scale, monitoring, interpolation polynomial, ecological factor.*

Introduction. Problem Statement. When developing a program for monitoring the system of man-made, natural and environmental factors in the territories and districts of an industrial enterprise, a problem often arises, which is associated with the formation of priorities for monitoring and evaluation of factors adversely affecting occupational safety. To solve this problem, it is necessary to create a fundamentally new toolkit for comprehensive assessment of different in nature factors of qualitative and quantitative nature in the system of adaptive monitoring [1, 2].

Analysis of publications. Based on the analysis of publications in the field of occupational safety, an approach can be identified to justify priorities in monitoring man-made, natural and environmental factors of areas and areas of industrial enterprise, based on methods common in probability theory, research and evaluation of working conditions. The availability of probabilistic information is due to the peculiarities of labor protection management system – the probabilistic nature of accidents and their consequences, the investigation of accidents, occupational diseases, accidents, establishing the degree of disability, and so on. This applies, first, to the accounting of working conditions carried out as a result of attestation of workplaces and information on the economic consequences of injuries and occupational diseases, without which it is impossible to plan effective measures for labor protection. Peculiarities of application of intellectualization the process of the decision-making were substantiated in the publication [3] without taking into account the possible use of the monitoring system [4] of man-made, natural and environmental factors in the territories of industrial enterprises. Another approach is based on the methods of expert assessments. Peculiarities of its application in view of environmental threats that are not formalized in terms of quantitative assessments, were considered to rank threats to biodiversity in Ukraine in the article [5].

The main goal of the article is to develop a mathematical model for determining priorities for monitoring natural, ecological and man-made factors that are significant and can be used in the decision-making support system for ensuring environmental safety in the natural-man-made geosystem of an industrial-urban agglomeration.

Research results. The purpose of this article is to substantiate the approach to ranking priorities based on analytical assessment of threats from man-made loads of industrial enterprises, based on quantitative assessments of indicators of ecosystem disturbances with subsequent impact on occupational safety indicators [6-8]. An appropriate methodology for their evaluation based on the application of stratification methods and interval scoring is proposed. Consider the structural and logical model of man-made impact of industrial production, which is shown in Fig. 1.

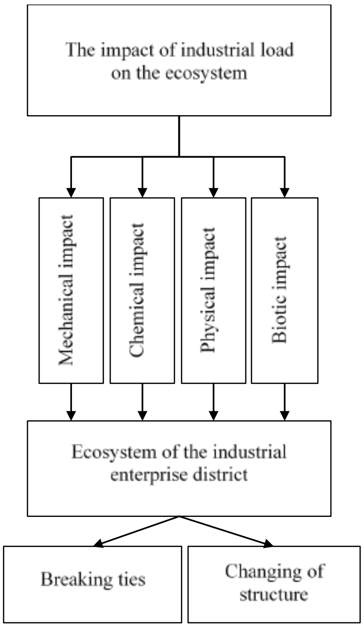

Fig. 1. Structural and logical model of man-made impact of industrial production on the ecosystem

Annex 9 to the "Procedure for Investigation and Accounting of Accidents, Occupational Diseases and Accidents at Work" (Resolution of the Cabinet of Ministers of Ukraine № 337 of April 17, 2019) presents a classifier of types of events, causes, equipment, machinery, mechanisms, vehicles, which led to an accident, acute occupational disease (poisoning), accident. Events coded 38–41 are referred to man-made, natural and environmental causes of occupational injuries.

Examples of defining prioritization for pollution monitoring are provided in publications [2, 3, 4, 5]. To address this task, criteria for determining prioritization are initially selected based on pollutant properties and measurement feasibility. Below are these criteria in summarized form:

1. The magnitude of actual or potential effects on human health and well-being, climate, or ecosystems (terrestrial and aquatic).
2. Susceptibility to degradation in the natural environment and accumulation in humans and trophic chains.
3. Potential for chemical transformation in physical and biological systems, leading to the formation of secondary (daughter) substances that may be more toxic or harmful.
4. Mobility and movement.
5. Actual or potential trends in concentrations in the environment and/or in humans.
6. Frequency and magnitude of impact.
7. Feasibility of measurements at various environmental levels.
8. Significance for assessing the state of the natural environment.
9. Suitability for widespread and consistent measurements in global and subregional ecological monitoring programs.

A large number of pollutants were assessed on a scale of 0 to 3 for each criterion. Priorities were determined based on the highest cumulative scores (higher scores indicate higher priority). These priorities, thus identified, were then divided into eight classes (higher class, i.e., lower ordinal number, indicates higher priority) with consideration of the environment and type of measurement program (impact, regional, "baseline", global). The resulting table (Table 1) of pollutants with assigned priorities and monitoring programs is provided below. Additionally, types of measurements for monitoring programs were listed for cases where pollutant measurement is challenging (indirect monitoring). For this purpose, measurements of the following parameters are needed:

a) Water quality indicators (coliform bacteria, BOD5, COD, blue-green algae, their primary productivity);

b) Soil quality indicators (salinity, pH, nitrite and organic nitrogen content, humus content);

c) Indicators of human and animal health, indicators of plant damage (incidence of diseases, genetic consequences, drug sensitivity);

d) Plant indicators of pollution.

Detailed analysis of input information, based on the principles of a systematic approach allows to form a structure of man-made, natural, environmental factors for specific typical causes of occupational injuries.

The use of an index-indicator approach to capture specific types of violations, including in the ecosystem as a result of adaptive environmental monitoring allows for a separate quantitative assessment of the impact on the relevant components of the ecosystem on a generalized scale.

Table 1

Classification of pollutants by priority classes [2, 3, 4]

Priority class	Pollutant	Medium	Type of program measurements
I	Sulphur dioxide plus suspended solids	Air	I, R, B
	Radionuclides (90Sr + 137Cs)	Food	I, R
II	Ozone	Air	I, B (in the stratosphere)
	DDT and other organochlorine compounds	Biota, human	I, R
	Cadmium and its compounds	Food, people, water	I
III	Nitrates, nitrites	Drinking water, food	I
	Oxides of nitrogen	Air	I
IV	Mercury and its compounds	Water, food	I, R
	Lead	Air, food	I
	Carbon dioxide	Air	B
V	Carbon monoxide	Air	I
	Petroleum hydrocarbons	Seawater	R, B
VI	Fluorides	Fresh water	I
VII	Asbestos	Air	I
	Arsenic	Drinking water	I
VIII	Microtoxins	Food	I, R
	Microbiological infection	Food	I, R
	Reactive hydrocarbons	Air	I

Note. B – basic (global), R – regional, I – impact.

Expert assessment of indices and indicators can be obtained using appropriate scales [9]. One of the most acceptable for quantitative indicators of disturbances in the ecosystem today is the interval scale. This scale in comparison with the nominal, ordinal and relative scales makes it possible not only to organize typical violations, but also to quantify and compare them.

As an interval scale for our case, you can choose a logarithmic scale or a scale obtained by the method of quadratic or cubic spline approximation [10, 11].

The method of constructing logarithmic scales that reflect the degree of disturbances in the ecosystem in the generalized indices B may be as follows:

$$B = \log_s I - \log_s a\,, \qquad (1)$$

$$B = \frac{\ln(I / a)}{\ln(s)}\,, \qquad (2)$$

where: a is the coefficient of proportionality that determines the limit value of the scale;
I – an indicator of typical disturbances in the ecosystem, which varies from the level considered acceptable for man-made load, to the value at which the ecosystem is disturbed,
s – is the basis of the logarithm, which determines the nature of the relationship between quantitative indicators and indices.

To determine the parameters of the interval logarithmic scale, you can use the formulas derived from expression (1):

$$B_{\max} = \frac{\ln(I_{\max} / a)}{\ln(s)}\,, \qquad (3)$$

from here $s^{B_{\max}} = \frac{I_{\max}}{a}$, $a = \frac{I_{\max}}{s^{B_{\max}}}$.

Another way to convert types of indicators violations to ecosystems, I in the evaluation index B is the use of spline-functions of 2nd order. Form an orderly grid of quantitative indicators of disturbances in the system of adaptive monitoring in. The task of interpolation in this case is to construct some function – interpolant, which in the nodes of the grid takes known values. To increase the accuracy of the approximation, you can increase the number of violations, which can worsen the situation as a whole. In this case, with the increased size of the grid nodes, the degree of interpolation function is created, in accordance with the growing error in calculating the values of this function, because, for practical reasons, customs-polynomial interpolation is used. For each interval of the grid we use a polynomial of the 2nd order, which will be called the spline function of the 2nd order. The main advantage of spline functions over conventional interpolation polynomials is the stability and simplicity of calculations.

The quadratic dependence has the form:

$$B = a + b \cdot (I - I_{\max}) + c \cdot (I - I_{\max})^2 \qquad (4)$$

The coefficients *a, b,* and *c* are calculated under the conditions specified. If $I = I_{\max}$, then (4) implies equality $a = B_{\max}$. Equating the first derivative $B'(I) = 0$ at a point $I = I_{\max}$, we obtain the value b=0. The coefficient c for the quadratic spline function is determined by the rule of calculating the minimum estimate of the index:

$$B_{\min} = a + c \cdot (I_{\min} - I_{\max})^2, \qquad (5)$$

$$c = \frac{(B_{\min} - B_{\max})}{(I_{\min} - I_{\max})^2}. \qquad (6)$$

In table 2 and in fig. 2 shows examples of 10-point logarithmic and quadratic scales for the indicator, which varies in the range from 1 to 150.

The methodology of substantiation of priorities in the system of ecological monitoring is based on the fact that the solution of the problem of expert assessment can be fully formalized by calculation methods, if possible by mathematical formalization of indicators of all disturbances in the ecosystem.

In practice, it is also convenient to use cubic splines $B_3(I)$ – splines of the 3rd order with a continuous first derivative. In order to construct a cubic spline, it is necessary to determine the coefficients a_{i0}, a_{i1}, a_{i2}, a_{i3}, which define the interpolation cubic polynomial:

$$Q_i(x) = B_{i,3}(x) = a_{i0} + a_{i1}x + a_{i2}x^2 + a_{i3}x^3 \qquad (7)$$

Let's mark:
$B_3(I_i) = B_i$; $B_3(I_{i+1}) = B_{i+1}$; $h = I_{i+1} - I_i$. We get:

$$B_3(I) = \frac{(I_{i+1} - I)^2(2\cdot(I - I_i) + h)}{h^3}\cdot B_i + \frac{(I - I_i)^2(2\cdot(I_{i+1} - I) + h)}{h^3}\cdot B_{i+1} + \frac{(I_{i+1} - I)^2(I - I_i)}{h^2}\cdot m_i + \frac{(I - I_i)^2(I - I_{i+1})}{h^2}\cdot m_{i+1} \qquad (8)$$

The value $m_i = B_3'(I_i)$ is called the slope of the spline in the node I_i.

Let's check:
$$B_3(I_i) = \frac{(I_{i+1} - I_i)^2(2\cdot(I_i - I_i) + h)}{h^3}\cdot B_i + \frac{(I_i - I_i)^2(2\cdot(I_{i+1} - I_i) + h)}{h^3}\cdot B_{i+1} +$$

Table 2

Logarithmic and quadratic scales of index estimation

	The score determined by formula (1)				The score according to the formula (4)
	s = 10	s = 5	s = 2	s = 1.75	
1	**7,823909**	**6,886717**	**2,771181**	**1,046294**	**1.008595**
2	8,124939	7,317394	3,771181	2,284907	1.12888
5	8,522879	7,886717	5,093109	3,922263	1,484875
10	8,823909	8,317394	6,093109	5,160876	2,062
25	9,221849	8,886717	7,415037	6,798233	3,671875
50	9,522879	9,317394	8,415037	8,036845	5.95
75	9,698970	9,569323	9.000000	8,761387	7,721875
100	9,823909	9,748070	9,415037	9,275458	8.9875
125	9,920819	9,886717	9,736966	9,674202	9,746875
150	10.000000	10.000000	10.000000	10,00000	10

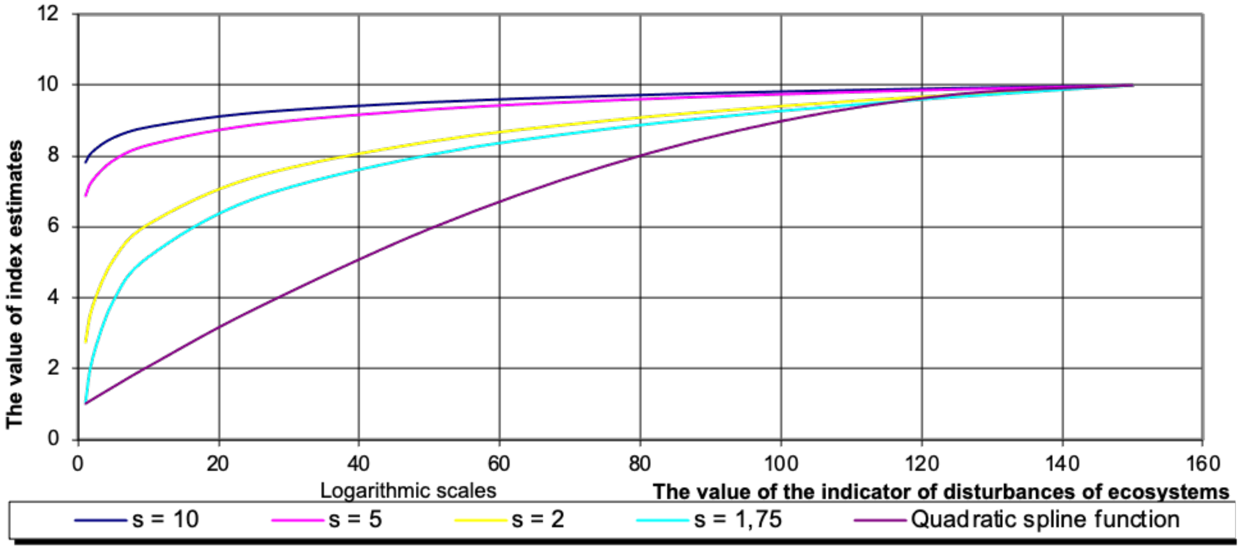

Fig. 2. Scale for evaluation of indicators of types of violations in the system of ecological monitoring

$$+\frac{(I_{i+1}-I_i)^2(I_i-I_i)}{h^2}\cdot m_i+$$

$$+\frac{(I_i-I_i)^2(I_i-I_{i+1})}{h^2}\cdot m_{i+1}=$$

$$\frac{(I_{i+1}-I_i)^2 h}{h^3}\cdot B_i=\frac{h^2}{h^2}\cdot B_i=B_i. \tag{9}$$

$$B_3(I_{i+1})=\frac{(I_{i+1}-I_{i+1})^2(2\cdot(I_{i+1}-I_i)+h)}{h^3}\cdot B_i+$$

$$+\frac{(I_{i+1}-I_i)^2(2\cdot(I_{i+1}-I_{i+1})+h)}{h^3}\cdot B_{i+1}+$$

$$+\frac{(I_{i+1}-I_{i+1})^2(I_{i+1}-I_i)}{h^2}\cdot m_i+$$

$$+\frac{(I_{i+1}-I_i)^2(I_{i+1}-I_{i+1})}{h^2}\cdot m_{i+1}=$$

$$=\frac{(I_{i+1}-I_i)^2 h}{h^3}\cdot B_{i+1}=B_{i+1}. \tag{10}$$

$$B_3^{'}(I_i)=\frac{-2\cdot(I_{i+1}-I_i)\cdot(2\cdot(I_i-I_i)+h)}{h^3}\cdot B_i+$$

$$+\frac{(I_{i+1}-I_i)^2\cdot 2}{h^3}\cdot B_i+$$

$$+\frac{2\cdot(I_i-I_i)\cdot(2\cdot(I_{i+1}-I_i)+h)}{h^3}\cdot B_{i+1}+$$

$$+\frac{(I_i-I_i)^2\cdot(-2)}{h^3}\cdot B_{i+1}+$$

$$+\frac{-2\cdot(I_{i+1}-I_i)\cdot(I_i-I_i)+(I_{i+1}-I_i)^2}{h^2}\cdot m_i+$$

$$+\frac{2\cdot(I_i-I_i)^2(I_i-I_{i+1})+(I_i-I_i)^2}{h^2}\cdot m_{i+1}=$$

$$=\frac{-2\cdot h^2+2\cdot h^2}{h^3}\cdot B_i+\frac{h^2}{h^2}\cdot m_i=m_i. \tag{11}$$

After performing similar calculations, we obtain $B_3^{'}(I_{i+1})=m_{i+1}$.

If a polynomial of the 3rd order takes at the points I_i and, I_{i+1} respectively, the values of B_i and B_{i+1}, and derivatives at these points, respectively, m_i and m_{i+1}, then this polynomial coincides with the polynomial (8).

The slope of the interpolation cubic spline can be set differently ways. The first, or simplified, method is to use formulas for numerical differentiation of the second order of accuracy with respect to the step *h*.

We put: $I_{\min}=I_0$; $I_{\max}=I_N$; $h=\dfrac{I_N-I_0}{N}$.

$$m_i=\frac{B_{i+1}-B_{i-1}}{2h},\, i=1,2,\ldots,N-1; \tag{12}$$

$$m_0=\frac{4\cdot B_1-B_2-3\cdot B_0}{2h};$$
$$m_N=\frac{3\cdot B_N-B_{N-2}-3\cdot B_{N-1}}{2h}. \tag{13}$$

The second method can be used if there is a value of the $B_i^{'}$ derivative B_i in the nodes of our grid I_i. In this case, you can put $m_i=B_i^{'}, i=0,1,\ldots,N$.

Both methods are local, because the spline is built separately on each partial segment $[I_i;I_{i+1}]$ using formula (7). The continuity of the first-order derivative in nodes is observed in such a construction, but the continuity of the second-order derivative cannot be guaranteed, so we assume that a cubic spline constructed by such an algorithm has a defect equal to two.

The problem of determining the cubic spline is significantly simplified by using the Hermitian polynomial. A cubic Hermitian polynomial on the interval *[I_{i-1}, I_i]* is determined using the function B_{i-1}, B_i and derivatives $B_{i-1}^{'}$, $B_i^{'}$. Since the values of the derivatives in the General case may be unknown, we denote them $m_i=B_3^{'}(I_i)$, $m_{i-1}=B_3^{'}(I_{i-1})$. As in the previous case of constructing a polynomial, the variables m_i are the slopes of the spline at the corresponding points I_i.

The following conditions must be met:

1. Function continuity condition:

$$Q_i(x_{i-1})=B_{i-1};\quad Q_i(x_i)=B_i. \tag{14}$$

2. Continuity conditions of the 1st and 2nd derivatives of the function:

$$Q'_i(I_i)=Q'_{i+1}(I_i);\quad Q''_i(I_i)=Q''_{i+1}(I_i). \tag{15}$$

3. Boundary conditions:

$$Q'_1(I_{\min})=B_{\min}^{'};\ Q'_{\max}(I_{\max})=B_{\max}^{'}$$

$$\text{or}\ \ Q''_1(I_{\min})=B_{\min}^{''};\ Q''_{\max}(I_{\max})=B_{\max}^{''}.$$

Often use the boundary conditions of the species:

$$Q''_1(I_{\min})=0\ \text{i}\ Q''_{\max}(I_{\max})=0 \tag{16}$$

The spline we get is called a natural cubic spline.

Denote $h_i=I_i-I_{i-1}$. We write the Hermitian polynomial or the interval *[I_{i-1}, I_i]*.

$$\begin{aligned}Q_i(I)&=B_{i-1}\frac{(I-I_i)^2(2(I-I_{i-1})+h_i)}{h_i^3}+\\&+m_{i-1}\frac{(I-I_i)^2(I-I_{i-1})}{h_i^2}+\\&+B_i\frac{(I-I_{i-1})^2(2(I_i-I)+h_i)}{h_i^3}+\\&+m_i\frac{(I-I_{i-1})^2(I-I_i)}{h_i^2}\ .\end{aligned} \tag{17}$$

The conditions of continuity of the function and its first derivatives are fulfilled: $Q_i(I_{i-1})=B_{i-1}$; $Q_i(B_i)=B_i$; $Q'_i(I_{i-1})=m_{i-1}$; $Q'_i(I_i)=m_i$.

In order to determine the spline, you need to set the conditions for the continuity of the second derivative:

$$Q''_i(I_i)=Q''_{i+1}(I_i). \tag{18}$$

In order to write these conditions in expanded form, we define a cubic Hermitian polynomial in the interval *[I_i, I_{i+1}]*, where $h_{i+1}=I_{i+1}-I_i$:

$$\begin{aligned} Q_{i+1}(I) = B_i \frac{(I - I_{i+1})^2(2(I - I_i) + h_{i+1})}{h_{i+1}^3} + \\ +m_i \frac{(I - I_{i+1})^2(I - I_i)}{h_{i+1}^2} + \\ + B_{i+1} \frac{(I - I_i)^2(2(I_{i+1} - I) + h_{i+1})}{h_{i+1}^3} + \\ +m_{i+1} \frac{(I - I_i)^2(I - I_{i+1})}{h_{i+1}^2} \quad . \end{aligned} \tag{19}$$

Now define the derivatives of the second order polynomials $Q_i(I)$ and $Q_{i+1}(I)$ at the point $I = I_i$:

$$Q''_i(I_i) = \frac{2m_{i-1}}{h_i} + \frac{4m_i}{h_i} - \frac{6(B_i - B_{i-1})}{h_i^2}; \tag{20}$$

$$Q''_{i+1}(I_i) = -\frac{4m_i}{h_{i+1}} - \frac{2m_{i+1}}{h_{i+1}} + \frac{6(B_{i+1} - B_i)}{h_{i+1}^2}. \tag{21}$$

The condition of continuity of the second derivatives has the form:

$$\begin{aligned} \frac{1}{h_i} m_{i-1} + 2(\frac{1}{h_i} + \frac{1}{h_{i+1}})m_i + \frac{1}{h_{i+1}} m_{i+1} = \\ = 3(\frac{B_i - B_{i-1}}{h_i^2} + \frac{B_{i+1} - B_i}{h_{i+1}^2}). \end{aligned} \tag{22}$$

For a natural cubic spline, it is convenient to use the condition:

$$Q''_1(I_{\min}) = 0; \; Q''_{\max}(I_{\max}) = 0. \tag{23}$$

One of these methods involves assigning scores to the types of ecosystem disturbances, which are determined using information on the quantitative characteristics of the indicator in the appropriate interval scales. Quantitative data on indicators are obtained as a result of observations by the information and measurement system of environmental monitoring. When using quantitative estimates, the relevant indicators are normalized.

To analyze the structure of violations from violations of machines and mechanisms, we use the method of stratification, which allows their distribution by strata. The obtained values of scores for the relevant types of violations for the three classes of object can be used to calculate a generalized expert score assessment of threats from industrial facilities in the formation of the environmental monitoring program.

A matrix of scores $B_{но}$ of ecosystem disturbances of an industrial facility is formed for each object according to the following scheme:

$$B_{но} = \begin{bmatrix} b_{11} & b_{12} & \ldots & b_{1n} \\ b_{21} & b_{22} & \ldots & b_{2n} \\ \ldots & \ldots & \ldots & \ldots \\ b_{m1} & b_{m2} & \ldots & b_{mn} \end{bmatrix}. \tag{24}$$

Line matrix corresponds executions anthropogenic load factors of industrial about the objects, column matrix – appropriate types of disturbances in the ecosystem caused by the activities of industrial enterprises. The elements of this matrix represent the scores obtained for the corresponding type of violation in the ten-point interval scale. Accordingly, for each stratum of man-made load factors.

The components of the eigenvector w_i $(i = \overline{1,m})$ are calculated in rows according to the formula:

$$\begin{aligned} w_1 &= [b_{11} \cdot b_{12} \cdot b_{13} \cdot \ldots \cdot b_{1n}]^{1/n}, \\ w_2 &= [b_{21} \cdot b_{22} \cdot b_{23} \cdot \ldots \cdot b_{2n}]^{1/n}, \\ &\ldots \\ w_m &= [b_{m1} \cdot b_{m2} \cdot b_{m3} \cdot \ldots \cdot b_{mn}]^{1/n}. \end{aligned} \tag{25}$$

Normalization of factors of technogenic loading objects is carried out by calculation of normalizing coefficients k_i $(i = \overline{1,m})$ according to the formula:

$$k_i = \frac{w_i}{\sum_{i=1}^{m} w_i}. \tag{26}$$

Then the priority vector is calculated $V_{во}$, which consists of components $(l = \overline{1,L})$, that are integral estimates of the corresponding first object for the corresponding n stratums:

$$\begin{aligned} V_{во1} &= k_{во11} \cdot w_{во11} + k_{во12} \cdot w_{во12} + \\ &+k_{во13} \cdot w_{во13} + \ldots + k_{во1m} \cdot w_{во1m}, \\ V_{во2} &= k_{во21} \cdot w_{во21} + k_{во22} \cdot w_{во22} + \\ &+k_{во23} \cdot w_{во23} + \ldots + k_{во2m} \cdot w_{во2m}, \\ &\ldots \\ V_{воL} &= k_{воL1} \cdot w_{воL1} + k_{воL2} \cdot w_{воL2} + \\ &+k_{воL3} \cdot w_{воL3} + \ldots + k_{воLm} \cdot w_{воLm} \end{aligned} \tag{27}$$

Based on the calculated vector of priorities, $V_{во}$ it is possible to rank the object according to the degree of man-caused load in the environmental monitoring system with the definition of priority measures and features of their implementation (volume, sequence and periodicity) for a typical object.

Conclusions. This methodology can be presented in the form of a comprehensive procedure for the formation of recommendations of the head of industrial enterprises and decision-makers on the formation of the program of environmental monitoring and decision-making on the prevention of occupational injuries. Thus, the results of research conducted according to the presented methodology can also be used in the development of a comprehensive plan of measures to minimize the impact of harmful man-made, natural and environmental factors to justify the priorities of the environmental monitoring system.

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Дерман В.А., Кругляк Г.В. МАТЕМАТИЧНА МОДЕЛЬ ВИБОРУ ПРІОРИТЕТІВ ПОКАЗНИКІВ СИСТЕМИ МОНІТОРИНГУ ТЕХНОГЕННИХ, ПРИРОДНИХ І ЕКОЛОГІЧНИХ ФАКТОРІВ

Програмно-апаратні засоби автоматизованої системи моніторингу параметрів навколишнього середовища в зоні впливу потенційно-небезпечних промислових об'єктів, які є джерелом небезпечних факторів впливу на довкілля та людський соціум, потребують математичного апарату для аналізу і обґрунтування рівня пріоритетів в програмі моніторингу небезпечних чинників та показників екологічного стану навколишнього середовища. Ця математична модель відіграє важливу роль у визначенні порядку і послідовності збору і аналізу даних про якість повітря, води, ґрунту та інших аспектів навколишнього середовища для автоматизованої системи. Такі автоматизовані системи екологічного моніторингу дозволяють не тільки отримувати відомості про рівні забруднення, хімічний склад, метеорологічні умови та інші показники навколишнього середовища, але і формувати корегуючі впливи в системі автоматизованого управління станом навколишнього середовища. Це надає можливість оцінити якість навколишнього середовища, провести функціональне зонування території моніторингу та вжити корегуючих заходів для зменшення впливу забруднення та покращення екологічного стану довкілля.

Стаття присвячена математичному моделюванню та системному підходу до визначення пріоритетів розвитку системи адаптивного моніторингу техногенних, природних факторів навколишнього середовища промислових підприємств. Наведено особливості формування інтервальної шкали для індексів та показників порушень екосистем, що знаходяться під впливом промислового навантаження. Особливістю формування даної статті є обґрунтування підходу до ранжування пріоритетів на основі експертно-аналітичної оцінки загроз від техногенних навантажень на території промислового підприємства на основі кількісної оцінки показників порушень екосистеми. Розроблену модель можна представити у вигляді комплексної процедури формування рекомендацій керівникам та окремим особам, яка дозволить об'єктивно оцінити варіанти супроводу управлінських рішень, проаналізувати можливі результати їх реалізації, обґрунтовано вибрати оптимальне рішення щодо вдосконалення системи екологічного моніторингу на підприємстві.

Ключові слова: *модель, охорона праці, інтервальна шкала, моніторинг, інтерполяційний поліном, екологічний фактор.*