Дослідження спрямовано на розроблення інструментів підтримки стратегічного екологічного оцінювання проектів розвитку різномасштабних територіальних утворень та урбоекосистем у поєднанні з концепцією оцінки впливів на навколишнє середовище. Запропоновано інструмент підтримки стратегічного екологічного оцінювання проектів розвитку різномасштабних територіальних утворень та урбоекосистем у поєднанні із ОВНС. Застосований підхід дозволяє встановити зв'язок між об'єктом, екосистемою та територією

Ключові слова: стратегічне екологічне оцінювання, оцінювання впливів на навколишнє середовище, екологічний ризик

Исследование направлено на разработку инструментов поддержки стратегической экологической оценки проектов развития разномасштабных территориальных образований и урбоэкосистем в сочетании с концепцией оценки воздействий на окружающую среду. Предложен инструмент поддержки стратегического экологического оценивания проектов развития разномасштабных территориальных образований и урбоэкосистем в сочетании с ОВОС. Примененный подход позволяет установить связь между объектом, экосистемой и территорией

Ключевые слова: стратегическая экологическая оценка, оценка воздействий на окружающую среду, экологический риск

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USING THE ASSESSMENT METHOD OF ENVIRONMENTAL RISK OF A PROJECT IN STRATEGIC TERRITORIAL PLANNING

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1. Introduction

At present, considerable efforts of the international community are aimed at solving environmental problems. Contemporary strategic environmental assessment is a systematic process of evaluating possible consequences of the implementation of plans for development of industrial regions. Methods of assessment of impacts of projected production activity on the environment allow quantitative measurement of the environmental risk. In practice, current quantitative methods of risk assessment are quite developed and well implemented. Therefore, determining the interaction of strategies and developed methods is a relevant task. This will give the opportunity to design the target programs of solving specific environmental problems of territories more reasonably. To reduce ecological tension, it is necessary to constantly assess the effects of economic activity on the environment. It is essential to seek optimal solutions that contribute to the prevention of possible adverse impact that may result in negative changes in the environment.

Consideration of environmental components in the decision-making process as early as at the stage of planning and design turns out to be much cheaper than taking measures of neutralization, compensation, and reimbursement of actual economic damage. As international practice shows, strategic environmental assessment (SEA) demonstrates high efficiency in solving similar problems. Environmental assessment may be performed at the level of individual projects (assessment of environmental projects) and at the level of "strategic" documents" (strategic environmental assessment).

2. Literature review and problem statement

Strategic documents, subject to SEA, include plans of development of territories or sectors of economy, programs, policies, strategies, etc. Thanks to SEA, foundations for environmental assessment of projects are laid at a higher level (development of programs/plans).

Currently, the most important legislative document that defines the minimum general procedures for SEA is the European Directive 2001/42/EC on assessing the environmental effects of implementation of specific plans and programs [1]. The Directive stipulates the procedure of conducting systematic evaluation, based on the environmental assessment of projects and SEA procedure that is open to participation of different stakeholders. Much attention in the Directive is paid to the elaboration of the environmental report.

The main provisions of the Directive on SEA made the basis of the Protocol on strategic environmental assessment to the Convention on the impact on environment in the trans-boundary context. The Protocol and the Directive are different in some aspects:

– the Protocol includes legislative acts as the objects of SEA;

– special attention in the Protocol is paid to assessment of effects on human health;

– the Protocol stipulates the need for public participation and consultation with stakeholders in the process of performing SEA.

Today, considerable material on performing the SEA in different countries of the world has been gathered, numerous monographs and guidelines on implementation of the SEA are published, the most effective approaches and methodology of conducting the SEA and involving the public are discussed, i. e. the problems of the SEA receive much attention in many countries [1–11].

In the CIS countries, SEA is considered a new tool for evaluation of strategic documents. Currently, the projects, aimed at building up the potential of effective implementation of SEA in the countries (Ukraine, Russia, Slovakia) are implemented, and pilot projects with the aim of gaining experience of SEA are realized. According to the Protocol on SEA, strategic environmental assessment implies "assessment of possible environmental consequences, including the impact on the health of the population, which includes definition of the scope of coverage and preparation of an environmental report, involvement of the public and arrangement of consultations, taking into account the environmental report and results of public participation and consultations in developing a plan or a program" [2].

Being fundamental, the provisions of the Directive [1] were developed in the Protocol on strategic environmental assessment to the Convention on the impact on environment in the trans-boundary context [3].

In their turn, the representatives of Ukraine in 2003 at the V All European Conference of Ministers of Environmental Protection "Environment for Europe" (Kiev, Ukraine) signed the Protocol on the SEA to the Convention on assessment of impact on environment (EIA) in the trans-boundary context. The protocol on the SEA was ratified in 2015 [4]. SEA is widely used in various types and forms and in many countries and continents (as of 2013, in more than 50 countries). In this respect, it is important to note that many countries had started to implement SEA even before joining the Protocol on SEA. In a number of countries that are not parties to the Protocol, SEA and similar assessments were conducted based on the national legislation (for example, in Canada and China). Its main advantages include a preventive nature of the procedure, which allows us to integrate conclusions into a program or a plan, thus preventing undesirable consequences. Another advantage is the use of an integrated approach to the evaluation of components of natural environment and human health. Experts and public are involved in the process as well.

Ukraine is trying to implement certain results of this work in the EU regarding preservation of natural environment through making territorial planning more ecologically friendly [6]. The problem is the lack of up-to-date full-scale territorial assessment of the environmental situation as a part of the projects of buildings and constructions. State city planning standards SCPS A.2.2-1-2003 [7] apply only to construction projects and have little to do with the territory infrastructure. Based on the necessity of strategic approaches, the EIA requires development of the territorial and strategic procedures. This is especially important for performing SEA of the regional programs involving industrial enterprises. The EIA results can serve as source data for further territorial planning, such as SWOT-analysis, or scenario analysis [8]. Quantitative assessment, in turn, may serve as indicators of strategies implementation.

The experience of implementing SEA along with EIA is widely used abroad [9], the studies have proven that SEA is one of the acceptable methods of achieving objectives of sustainable development, in which administrative policies, plans and programs are evaluated on a regular and comprehensive basis.

Integration of performance indicators of a project according to EIA in the model of a region will make it possible to evaluate negative effects and minimize environmental risk. Such possibilities of SEA and EIA application are revealed in paper [10], which proves the need for development of EIA and approaches to risk estimation. Assessment of strategic risks is the focus of the work [11], which proposes to apply expert and socio-economic evaluations, but this work bears a more conceptual character.

The object of the study is to explore the relationship of SEA and EIA in developing approaches to evaluation of the environmental risk of technogenic projects. A challenge in this study is the fact that SEA has only a descriptive character and at present, the intense work on drafting the laws concerning conducting SEA in Ukraine is in progress.

3. The aim and tasks of research

The aim of present research is development of support tools for strategic environmental assessment of projects of development of territorial formations and urbo-ecosystem of diverse scales along with EIA.

To achieve this aim, it is necessary:

– to explore the state of the problem of SEA in Ukraine;

– to establish relationship between SEA and EIA;

– to offer the procedure of ecological safety evaluation of territorial formations for conduct a strategic environmental assessment.

4. Comparison of procedures of ecological analysis

After studying the procedures of EIA and SEA, it is possible to distinguish the following differences that are presented in Table 1.

For the SEA procedure to be effective and to provide environmental considerations, it is imperative to coordinate SEA with drafting the following documents:

– strategic environmental assessment, fully integrated into the process of drafting planning documents;

– strategic environmental assessment, partially integrated into the process of drafting planning documents;

– strategic environmental assessment, performed retrospectively or in isolation from the planning process.

Table 1

Comparison of procedures of environmental assessment

Assessment of environmental impacts	Differences between AIE and SEA	Strategic environmental assessment
Individual projects	Solution level	Documents of strategic planning
Combination of issues of project significance and technical problems	Tasks statement	Integration policy issues, discussions with stakeholders and expert opinions
Field research, sample analysis, statistics	Main data sources	Reports on state of environment, literature and stock materials, statistics, current and prospective plans and programs, standardizing and legal acts
Mainly quantitative	Data	Mainly qualitative, descriptive
More precise	Precision level in revealing impact	Less precise
Projects, technology implementation	Alternatives	Objectives and priorities of a program; alternative activities; alternative implementation conditions
Ecological substantiation of eligibility of a project, necessary environmental measures	Result	Ecological and social substantiation of prevailing alternatives, territorial schemes

The procedure of EIA also needs revision with respect to:

– inadequate tackling territorial issues in the EIA methodology;

– the lack of EIA in designing plans, programs and policies at the local or state levels in the construction industry [12, 13].

The prospect of EIA development is to distinguish the following sections:

– EIA of designed project (project EIA);

– EIA of engineered territories, necessary for implementation of regional planning schemes, general city planning, industrial centers, projects of regional development (territorial EIA);

– EIA of designed plans, programs and policies at the local or state levels in the construction field (strategic EIA).

In terms of harmonization of human and nature interaction, it is considered appropriate to develop and implement the State building standards as for the project, territorial and strategic EIA in conjunction with the concept of SEA.

The project EIA contains:

1. Information about the documents, which are the basis for development of the EIA development as a part of an investment program or project.

2. List of sources of potential impact of planned activity on the environment considering its alternative options.

3. A brief description of the types of impact of planned activity on the environment and their enumeration.

4. List of environmental, sanitary-epidemiological, fire safety and urban planning restrictions.

5. Information about the attitude of the public and other stakeholders to the planned activity and associated problems that need solving.

6. List of standardizing-methodical documents.

7. Description of methods of predicting environmental indicators dynamics and substantiation of the forecast calculation periods.

8. Information about structural units of the performer and a list of subcontractors and specialists performing EIA.

9. Enumeration and brief analysis of previous approvals and evaluations, including public examination; enumeration of information sources, used in the development of EIA [14].

The purpose of the territorial EIA is objective definition of acceptability and expediency of territory planning or placing a single environmentally dangerous project by the environmental safety criterion and fixing objective environmental aspects of planning in the legal field. In the territorial EIA, it is necessary to foresee [14]:

1. Maximally possible provision of acceptable living conditions for the population and serviceability of the existing sites.

2. Consider the ecological state of the territory.

3. Determine its unauthorized changes to the estimated construction period.

4. Only with a positive result, to develop the planned projects so as not to violate the acceptable sanitary norms.

In the strategic EIA, it is necessary to foresee assessment of the impact on environment, made by developed plans, programs and policies at the local or state levels in the construction industry [14].

The combination of the basic provisions of SEA and the improved EIA procedures will make it possible to create the procedure of evaluation of ecological safety of territorial formations to conduct strategic environmental assessment. It is advisable to use an indicator of ecological risk of technogenic projects as a basic indicator of environmental safety, which is substantiated by the authors of paper [15].

While evaluating ecological risk, it was proposed to apply the project approach taking into account the stage of the life cycle of a technogenic project. A special case, which is characterized by considerable uncertainty, is an emergency that may be of natural or technogenic origin.

5. The results of research. Definition of ecological risk for strategic design of territories

Strategic environmental assessment is the methodology of sustainable development of territories. Methods of EIA are a tool of putting designs of industrial environmental systems into practice.

The authors designed a method of assessment of ecological risk of the planned industrial projects [16, 17], which in this work was developed for territorial formations.

The basis of the proposed method includes dependences for determining ecological risk (1)–(3) [16, 17]:

$$R_E = \sum_{i=1}^{m} r_i, \tag{1}$$

$$r_i = a_i \cdot e^{b_i \cdot I_i}, \tag{2}$$

$$r_{i,k} = c_i \cdot e^{d_i \cdot I_{i,k}}, \qquad (3)$$

– R_E – integral ecological risk;

– r_i – risk of changes in the state of the i-th environmental component (EC) (atmosphere, surface water, soil);

– a, b – calculation coefficients, connected with specificity of the EC component (Table 2);

– e – exponential function;

– I_i – index of assessment of the level of environmental hazard of the impact on the i-th EC component;

– $r_{i,k}$ – risk of changes in the state of the i-th EC component of the k-th substance (for assessment of individual impact of every substance);

– c, d – calculation constants associated with substance specificity of the EC component ($c=1\cdot10^{-8}$, $d=4.931$);

– $I_{i,k}$ – index of assessment of the level of environmental hazard of the impact of the k-th substance on the i-th EC component.

Coefficients that are related to specificity of the EC component (Table 2), were obtained using the nonlinear regression method for functions of type (2). The source data were the levels of the scale of assessment of environmental hazard of the impact on the EC components (I_i) [16, Table 3] and the levels of classification of risk of changes in the EC state (Table 3) (r_i). The calculation procedure was implemented in the Mathcad programming package, the results of calculation are presented in Fig. 1 (taking the atmosphere as an example).

Evaluation of the level of risk of changes in the state of the i-th EC component is carried out in accordance with the proposed scale (Table 3).

Based on the resulting value, we make the decision about acceptability of the project by each pollutant as for the EC component on the whole.

At each stage of the life cycle of the project, there are threats of irreversible changes in natural environment that can be measured with values of ecological risk.

When developing methods of making optimal decisions, the project approach is most acceptable. An object that is on the certain territory may be informatively described by vector function of $\Phi(\vec{\alpha})$, form, and the vector of parameters of a project $\vec{\alpha}$ may be found by dependence (4):

$$\vec{\alpha} = \begin{Bmatrix} y_1(x_1, x_2, ..., x_k) \\ y_2(x_1, x_2, ..., x_k) \\ .... \\ y_n(x_1, x_2, ..., x_k) \end{Bmatrix}, \qquad (4)$$

where $y_i(x_1, x_2, ..., x_k)$ is the function describing the i-th property of a project, which is defined by totality k of source variables. In a particular case, the function may be a constant.

The values of properties of a project are considered depending both on the stages of the life cycle, and on possibility of emergency occurrence. If the industrial ecological system is seen as a multi-parameter project, it may be informatively described similarly to expression (4).

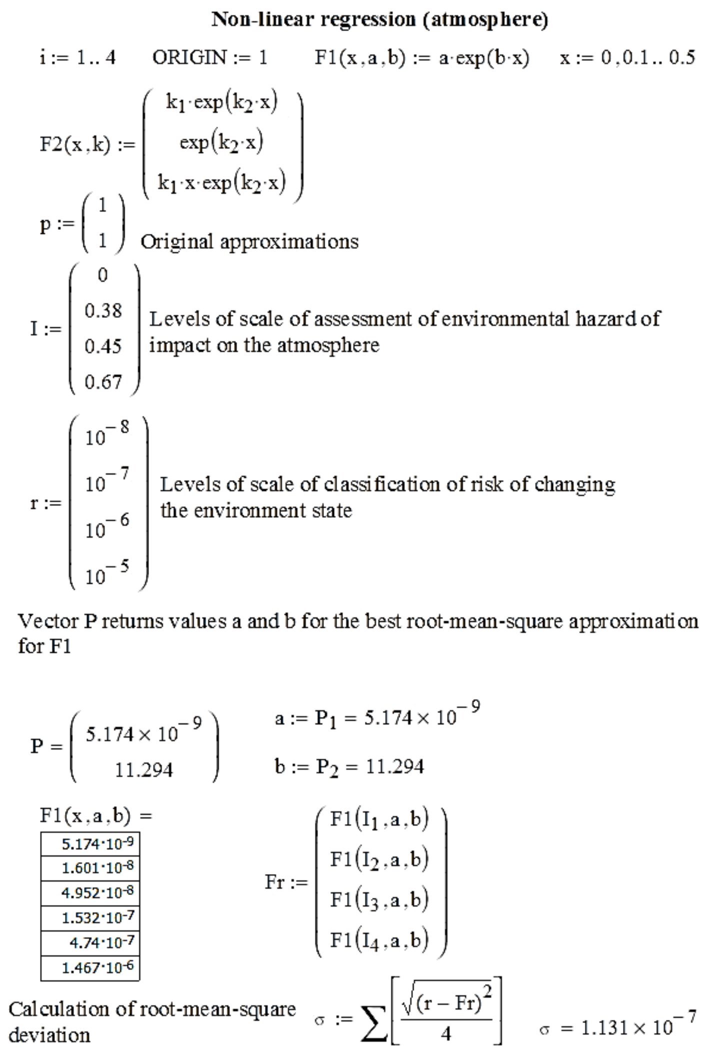

Fig. 1. Results of calculation of coefficients a and b (taking the atmosphere as an example)

Table 2

Calculation coefficients

Impact on the environment	Values of coefficients	
	a_i	b_i
Chemical pollution of the atmosphere (i=1)	$a_1=5.17\cdot10^{-9}$	$b_1=11.29$
Chemical pollution of surface waters (i=2)	$a_2=4.84\cdot10^{-13}$	$b_2=21.054$
Chemical pollution of soils (i=3)	$a_3=6.083\cdot10^{-8}$	$b_3=5.48$
Noise pollution (i=4)	$a_4=1\cdot10^{-6}$	$b_4=-37.05$
Infrasound pollution (i=5)	$a_5=8\cdot10^{-10}$	$b_5=7.67$
Ultrasound pollution (i=6)	$a_6=1\cdot10^{-8}$	$b_6=6.89$
Electromagnetic, vibration pollution (i=7–14)	$a_{7\text{-}14}=1\cdot10^{-8}$	$b_{7\text{-}14}=4.95$
Radioactive pollution (i=15)	$a_{15}=2.47\cdot10^{-9}$	$b_{15}=8.93$

Table 3

Classification of levels of risk of changes in the state of environment

Level	Value of risk R_E, r_i
Unacceptable	$>10^{-6}$
Conditionally acceptable	10^{-6}–10^{-7}
Acceptable	10^{-7}–10^{-8}
Unconditionally acceptable	$<10^{-8}$

The interaction of a technological project and the industrial environmental system is described by the matrix of interactions. The change of properties of an industrial project will cause a change in properties of the system. The matrix of interactions has the following form:

$$M=\begin{bmatrix} m_{11}\ ...m_{1i}....m_{1n} \\ m_{21}\ ...m_{2i}....m_{2n} \\ ... \\ m_{j1}\ ...m_{ji}....m_{jn} \\ ... \\ m_{n1}\ ...m_{ni}....m_{nn} \end{bmatrix}, \qquad (5)$$

where m_{ij} is the element that shows whether there is a relationship between a project and a system or not. This relationship may be realized by several parameters.

It should be noted that definition of the components of expressions (4) and (5) is such a difficult task that for practical usage there occurs considerable uncertainty even for small projects. Given that interaction between the components of the ecological system with a project is characterized by the appropriate value of risk, its definition will greatly simplify the problem.

If, on the one hand, it is possible to use expression (4) to describe a project, and on the other hand, to use the index to evaluation of the level of environmental hazard as its property, then for the inverse problem, it is easy to obtain the following dependence [16, 17]:

$$I_{ij}=\frac{1}{b_j}\ln\left(\frac{r_i}{a_j}\right). \qquad (6)$$

In paper [17], it was proved that the index of evaluation of the environmental hazard level is calculated according to mathematical dependence (7):

$$I_{ij}=1-e^{-e(-y_j')}, \qquad (7)$$

where y_j' is the corresponding indicators of pollution of the j-th EC component.

Then, y_j' may be calculated by dependence (8):

$$y_j'=\ln\left(\ln\left(1-\frac{1}{b_j}\ln\left(\frac{r_i}{a_j}\right)\right)\right). \qquad (8)$$

Thus, indicators of pollution of the EC components are represented in Table 4 (for certain pollutants) and Table 5 (for integral indicators).

Table 4

Indicators y′, considering special features of industrial project (by pollutant)

EC component	Mathematical dependence y'	Conditional designations
Atmosphere (i=1)	$y_{ik}'=-2\cdot PS_k+1$ $PS_k=C_k/(BRC_k\cdot K_k)$	PS_k is the indicator of pollution of the k-th substance; C_i is the mean daily concentration of the k-th substance, mg/m³; BPC_k is the boundary permissible concentration, mg/m³; K_k is the values of coefficients that consider the hazard class of the k-th substance
Surface waters (i=2)	$y_{ik}'=-2\cdot I_k+1$, $I_k=C_k/BPC_k$	I_k is the index of the k-th polluħ tion indicator; C_k is the substance concentration (in a number of cases, values of physical-chemical parameter are used), mg/l; BPC_k is the found magnitude of standard for corresponding type of water site, mg/l
Soils (i=3)	$y_{ik}'=-2\cdot Cc_k+1$, $Cc_k=C_k/Cb_k$	Cc_k is the coefficient of chemical substance concentration; C_k is the factual content of pollutant in soils, mg/kg; Cb_k is the background content of pollutant in soils, mg/kg

Table 5

Indicators y_j', considering special features of industrial project (by integral indicators)

EC component	Mathematical dependence y'	Conditional designations
Atmosphere (i=1)	$y_i'=-0,25\cdot ME+1$	ME is the multiplicity of excess of standards
Surface waters (i=2)	$y_i'=-0,33\cdot I_E+1,33$	I_E is the integral ecological index
Soils (i=3)	$y_i'=-0,016\cdot Zc+1$	Zc is the total pollution indicator

According to data of Table 4, 5, it is possible to make generalization:

$$y_{ik}'=k_1y_{ik}+k_2, \qquad (9)$$

where k_1, k_2 are the calculation coefficients.

An important task is the calculation of functions (4), considering the features of a project. With regard to (8), (9) we have:

$$\ln\left(\ln\left(1-\frac{1}{b_j}\ln\left(\frac{r_i}{a_j}\right)\right)\right)=k_1y_{ij}+k_2,$$

$$y_{ij}=\frac{1}{k_1}\left(\ln\left(1-\frac{1}{b_j}\ln\left(\frac{r_i}{a_j}\right)\right)\right)-\frac{k_2}{k_1}. \qquad (10)$$

The values of coefficients k_1, k_2 are presented in Table 6.

Table 6

Calculated coefficients k_1, k_2

EC component		Coefficients	
		k_1	k_2
Atmospheric air	by substance	−2	1
	on the whole	−0.25	1
Surface waters	by substance	−2	1
	on the whole	−0.33	1.33
Soils	by substance	−2	1
	on the whole	−0.016	1

The coefficients of interactions m_{ij} of matrix M (5) may be calculated according to mathematical dependence (11):

$$m_{ij}=\beta \cdot y_{ij}, \quad (11)$$

– β is the information matrix of parameters of a project, considering the specifics of location of industrial project on certain territories [15]. The elements of matrix β may take values of 0 and 1, which indicate the impact absence or presence respectively;

– indices i, j indicate the EC component and a pollutant respectively.

The magnitude of the potential of territorial risk represents the maximum value for specific projects of influence in a given point of space, which may be interpreted by concentration circles from origin of coordinates. In practice, it is important to know the distribution of the potential risk for individual sources of danger.

6. Discussion of the results of strategic environmental assessment on the example of a power substation

Environmental assessment was performed for the project of construction of additional power substation on the territory of the plant.

Arrival of pollutants into the atmospheric air may potentially occur at the stage of operation and at the stage of construction of a project. The sources of air pollution during the operation are fans of the inflowing-exhaust system. Based on the analysis of the nature of the used technological equipment at the substation and its work, it may be noted that there are no sources of pollutants formation in the atmosphere during the operation. The sources of air pollution during construction will include operating construction mechanisms and transport, as well as dusty materials, carelessly stored in temporary storages, and excavation works.

In accordance with the operating project for the period of construction, the following types of work, related to pollutant formation, are foreseen:

– excavation works (excavations from pits and trenches, back filling);

– mounting of concrete, reinforced concrete and construction steel structures with the use of welding;

– mounting of technological equipment;

– device of sand foundation; work of vehicles and machinery on the construction site.

Key performance indicators and results of calculation of quantitative indicators of atmospheric pollution are presented in Table 7, 8.

The largest emissions are related to nitrogen dioxide and dust, but they do not exceed the BPC, therefore special protective measures during construction works are not required. As it may be seen from the obtained results (Table 8), considering the level of pollution of atmospheric air, the state of the power substation project is estimated as conditionally acceptable.

Samples of soils for the content in of pollutants were taken on three grounds.

According to the data (Table 9, 10) of the actual content of heavy metals in soil samples on the grounds of power substation, in general, soils are not contaminated.

As it may be seen from the obtained results (Table 11), considering the level of contamination of soils, the state of the power substation project is estimated as conditionally acceptable.

According to the object approach to evaluation of ecological safety, we will compile the matrix of coefficients M (12):

$$M=\begin{array}{cl}\begin{bmatrix} 0{,}689 & 0 & 0 \\ 0{,}698 & 0 & 0 \\ 0{,}692 & 0 & 0 \\ 0{,}687 & 0 & 0 \\ 0{,}685 & 0 & 0 \\ 0{,}686 & 0 & 0 \\ 0{,}739 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1{,}411 \\ 0 & 0 & 1{,}111 \\ 0 & 0 & 4{,}091 \\ 0 & 0 & 0 \\ 0 & 0 & 1{,}858 \\ 0 & 0 & 4{,}091 \\ 0 & 0 & 0 \\ 0 & 0 & 0{,}724 \\ 0 & 0 & 4{,}091 \end{bmatrix} & \begin{array}{c} Mn \\ NO_2 \\ Soot \\ SO_2 \\ CO \\ C12-C19 \\ \text{Dust from } SiO_2 \\ Hg \\ Pb \\ Zn \\ Cu \\ Cr \\ Ni \\ Ba \\ Br \\ Sr \\ Cd \end{array}\end{array}. \quad (12)$$

Table 7

Indicators of pollution of air basin in the period of construction works

No. of entry	Substance	BPC mg/m^3	C mg/m^3	Hazard class	Pollution indicator PS	Index by substance I	Risk r	Value y
1	Manganese Mn	0.01	0.0003	2	0.0150	0.3155	$4.74\cdot10^{-8}$	0.689
2	Nitrogen dioxide NO_2	0.09	0.0066	2	0.0366	0.3269	$5.01\cdot10^{-8}$	0.698
3	Soot	0.15	0.0092	3	0.0204	0.3183	$4.81\cdot10^{-8}$	0.692
4	Sulphur dioxide SO_2	0.50	0.0118	3	0.0078	0.3118	$4.65\cdot10^{-8}$	0.687
5	Carbon oxide CO	5.00	0.0590	4	0.0029	0.3093	$4.60\cdot10^{-8}$	0.685
6	Carbon C12-C19	1.00	0.0177	4	0.0044	0.3101	$4.61\cdot10^{-8}$	0.686
7	Dust with SiO_2	0.30	0.1179	3	0.1310	0.3800	$6.51\cdot10^{-8}$	0.739

Table 8

Quantitative indicators of atmospheric pollution

Indicator	Values of indicators
Total indicator of atmospheric pollution	62.118
Boundary permissible pollution	264.323
Multiplicity of excess	0.236
Index of atmospheric pollution	0.323
Risk of influence of a site on atmosphere	$1.99 \cdot 10^{-7}$
Value y	5.56
Risk level	Conditionally acceptable

Table 9

Data of actual content of heavy metals in soil samples on the ground of power substation

No. of entry	Indicator	Background concentrations of soil, Cb mg/m^3	Concentration and coefficient of pollution of soils					
			Sample No. 1		Sample No. 2		Sample No. 3	
			C, mg/m^3	Cc	C, mg/m^3	Cc	C, mg/m^3	Cc
1	Mercury Hg	0.01	–	–	–	–	0.1	10
2	Plumbum Pb	10	8	0.8	6	1.7	17	1.7
3	Zink Zn	50	30	0.6	110	2.2	105	2.1
4	Copper Cu	20	10	2	20	1	30	1.5
5	Chromium Cr	90	–	–	2	0.02	–	–
6	Nickel Ni	40	20	1	30	0.75	30	0.75
7	Barium Ba	50	25	3.2	180	3.6	160	3.2
8	Bromine Br	5	–	–	–	–	14	2.8
9	Strontium Sr	300	30	0.1	25	0.083	40	0.13
10	Cadmium Cd	0.5	0.2	3.4	1.8	3.6	–	–

Table 10

Results of calculation of quantitative indicators of environmental safety for soils

No. of entry	Indicator	Quantitative indicators of environmental safety					
		Sample No. 1		Sample No. 2		Sample No. 3	
		Risk r_k	y	Risk r_k	y	Risk r_k	y
1	Mercury Hg	–	–	–	–	$1.38 \cdot 10^{-6}$	4.091
2	Plumbum Pb	$6.24 \cdot 10^{-7}$	1.411	$1.38 \cdot 10^{-6}$	4.091	$1.38 \cdot 10^{-6}$	4.091
3	Zink Zn	$3.24 \cdot 10^{-7}$	1.111	$1.38 \cdot 10^{-6}$	4.091	$1.38 \cdot 10^{-6}$	4.091
4	Copper Cu	$1.38 \cdot 10^{-6}$	4.091	$1.00 \cdot 10^{-6}$	1.858	$1.38 \cdot 10^{-6}$	4.091
5	Chromium Cr	–	–	$4.80 \cdot 10^{-6}$	0.691	–	–
6	Nickel Ni	$1.00 \cdot 10^{-6}$	1.858	$5.37 \cdot 10^{-7}$	1.325	$5.37 \cdot 10^{-7}$	1.325
7	Barium Ba	$1.38 \cdot 10^{-6}$	4.091	$1.38 \cdot 10^{-6}$	4.091	$1.38 \cdot 10^{-6}$	4.091
8	Bromine Br	–	–	–	–	$1.38 \cdot 10^{-6}$	4.091
9	Strontium Sr	$5.96 \cdot 10^{-8}$	0.724	$5.68 \cdot 10^{-6}$	0.717	$6.49 \cdot 10^{-6}$	0.738
10	Cadmium Cd	$1.38 \cdot 10^{-6}$	4.091	$1.38 \cdot 10^{-6}$	4.091	–	–

Table 11

Quantitative indicators of pollution of soils and risk of impact on soils

Indicator	Sample No. 1	Sample No. 2	Sample No. 3
Total indicator of soil pollution	11.100	12.956	22.183
Index of soils pollution	0.3556	0.3640	0.4082
Risk of impact of a site on soils	$4.27 \cdot 10^{-7}$	$4.47 \cdot 10^{-7}$	$5.7 \cdot 10^{-7}$
Value y	89.97	90.78	95.30
Level of risk of impact on soils	Conditionally acceptable	Conditionally acceptable	Conditionally acceptable

In matrix M (12), the first three columns characterize the results of environmental assessment of impact of relevant pollutants (the last column) on the EC components: atmosphere, surface waters and soils, respectively. The calculated results show existence of a relationship between the project and the system with regard to the lack of impact on surface waters (by soils for sample No. 1). The obtained values are distributed on the territory of the enterprise with regard to sanitary-protective zone.

7. Conclusions

1. It was found that it is a challenge that SEA bears only a descriptive character, however, at present, the intensive work on drafting laws on implementing SEA in Ukraine is in process.

2. The tool of supporting strategic environmental assessment of projects of development of territorial formations and urbo-ecosystems of different scales along with EIA was developed. The procedure of evaluation of ecological safety of territorial formations for conducting strategic environmental assessment was proposed. This procedure is based on the application of techniques based on the use of indices and environmental risks. In this case, we used the project approach that allows us to establish relationship between a project and its territory.

3. Testing of the proposed approach on the example of the power substation project was carried out, quantitative indicators of pollution of the atmosphere and soils were calculated. The matrix of correlations of the object of research and environmental system for the purpose of establishing relationship between the project and the system was constructed.

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