THE ASSESSMENT ANTHROPOGENIC IMPACT OF INDUSTRIAL OBJECT FOR ECOLOGICAL SYSTEM BASED ON INTEGRATED CRITERION

ОЦЕНИВАНИЕ ТЕХНОГЕННОЙ НАГРУЗКИ ПРОМЫШЛЕННОГО ОБЪЕКТА ЭКОЛОГИЧЕСКОЙ СИСТЕМЫ НА ОСНОВЕ ИНТЕГРАЛЬНОГО КРИТЕРИЯ

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Abstract: *This article explores the main problems of assessment of anthropogenic impact on the ecological system of the projected industrial facility. It proposed used as an indicator of environmental risk as an integral criterion. The calculation of risk is based on the method of "risk index".*
***KEYWORDS**: PROJECTED INDUSTRIAL FACILITIES, HUMAN IMPACTS, INDEX, ENVIRONMENTAL RISK, INTEGRAL CRITERION*

1. Introduction

Currently, there is a human impact on the ecosystem Ukraine due to pollution of the environment by chemical, metallurgical, mining industries, nuclear, thermal power plants, sugar plants, road, and drainage systems. Industry influences on the ecosystem mainly through of their direct destruction particularly as a result of emissions into the atmosphere and hydrosphere pollutants.

The main task for the near future is to minimize the increase of anthropogenic impact on the environment. Therefore, the development approach to the assessment of anthropogenic impact on the implementation of the industrial ecological system designed industrial facilities is a topical direction of research.

2. Background and means for solutions problems

The *object* of research is assessment of projected impacts of industrial facilities on the ecological system to determine the anthropogenic impact.

The main purpose of evaluation of anthropogenic impact of projected industrial facilities is accumulation, systematization, and analyzing information about the quantitative connection between industrial objects and the environment.

This assessment is carried out to obtain the following results:

- estimates quality of components of the environment;
- identify the causes of adverse disorders in the environment, establishing sources and factors of negative external influence;
- predicting the admissibility of impact on the environment in general;
- identifying the most dangerous impacts and comparing the contribution of various types of impacts.

There are many normative methods to assess the contribution of various factors of environmental impact.

The most simple and common method is a method that involves comparing the obtained quantitative estimates with approved standards which applied at the design stage industrial facility [1].

Today, the definition of risks at the design stage is a compulsory procedure of Environmental Impact Assessment (EIA) [1].

In accordance with the publication [2], risk is considered as the probability of adverse effects on human health and does not account for the impacts from the industrial facilities at the design stage; the authors proposed a mathematical based on assessment of such risk.

In the publication [3] the authors propose to use the integral environmental indices in the assessment of anthropogenic impact on atmospheric air, surface water, soil that can be used in the EIA procedure, but the mathematical correlations do not offer.

In the publication [4] propose methods for assessment of environmental safety with the use of indices and risk assessments. The authors not offered the quantitative procedures for determining these estimates.

In the publication [5] it was investigated the main causes which create risks and affect the condition of environmental safety.

The authors of the publication [6] have analyzed the threats to human health. Risk assessment is proposed should consider the impacts and danger on the human body; the design stage of the object is not taken into account.

The authors of the publication [7] propose to use a probabilistic approach to the evaluation of environmental risks with the use of probabilistic models. This approach cannot be applied at the design stage. This is due to a lack of information about the distribution function of the parameters of random variables as well as incomplete statistics on the equipment failures and the occurrence of various negative events.

It is necessary to build integral criterion for the practical estimation of anthropogenic impact at the design stage. This approach summarizes the groups of indicators and gives the possibility to quantify the influence of man-made object at the design stage and continue to make decisions regarding the acceptability of introducing such a facility in the industrial ecosystem.

Thus, the development of dependency of the assessment of environmental risk as integral criterion using the index ratings in the EIA is a topical area of research.

3. The solution of the problem

Develop an approach to the assessment of the anthropogenic impact with the use of environmental risk as integral criterion is the solution of the problem.

For calculating environmental risk as integral criterion of estimation of anthropogenic impact at the design stage it is necessary to consider the impact; realize industrial facility on the ecosystem.

In case of insufficient source information at the design stage it is proposed to use developed by the authors estimates calculated using the desirability function Harrington with the use of benchmarks that implicit in the methodology of the EIA [8, 9].

In general, the unified index evaluation of the level of influence has the form (1) [8, 9]:

$$I_i = 1 - d_i = 1 - e^{-(e^{-y_i'})}, \quad (1)$$

where I_i – index evaluating for the *i*-th type of the impact of an industrial facility on the environment, dimensionless, d_i – desirability function of the impact of an industrial facility on the environment, dimensionless, e – exponent; y_i' – quantitative indicator that takes into account the industrial object for the *i*-th type of impact the components of the environment that is

associated with a quantitative indicator $П_i$ (determined in accordance with the norms of Ukraine).

To calculate anthropogenic impact on the ecological system is proposed to use the indexes the chemical and physical effects of the projected industrial facility on the environment (tabl.1, tabl.2) [8, 9].

Table 1. *Indices for evaluation of chemical impact of projected industrial facilities*

Component of the environment	Mathematical dependence for the index definition	Legend
Atmos-phere *(i=1)*	$I_i = 1 - e^{-(e^{0,25 \cdot КП - 1})}$	*КП* – the multiplicity of regulatory excess pollution, dimensionless;
Surface water *(i=2)*	$I_i = 1 - e^{-(e^{0,33 I_E - 1,33})}$	I_E – the integral ecological index, dimensionless;
Soil *(i=3)*	$I_i = 1 - e^{-(e^{0,016 \cdot Zc - 1})}$	*Zc* – the total index of soil pollution, dimensionless.

Table 2. *Indices of the assessment of the physical impacts of projected industrial facilities*

The impact parameters	Mathematical dependence for the index definition	Legend
Noise *(i=4)*	$I_i = e^{-(e^{(0,025 \cdot L_A - 1)})}$	L_A – noise level;
Infrasound *(i=5)*	$I_i = 1 - e^{-(e^{(0,1 \cdot \Delta L - 1)})}$	ΔL – sound pressure level;
Ultrasound *(i=6)*	$I_i = 1 - e^{-(e^{(0,01 \cdot Lvg - 1)})}$	*Lvg* – logarithmic vibration level;
Electro-magnetic impact *(i=7)*	$I_i = 1 - e^{-(e^{2 \cdot W - 1})}$	*W* – maximum allowable value of the energy flux density;
Vibration *(i=8)*	$I_i = 1 - e^{-(e^{(0,018 \cdot Lv - 1)})}$	*Lv* – logarithmic vibration level;
Radiation exposure *(i=9)*	$I_i = 1 - e^{-(e^{0,0015 \cdot A_{ef} - 1})}$	A_{ef} – total effective specific activity of natural radionuclide.

On the basis of the index values, you can set the level of effects on components of the environment. It is proposed to conduct evaluations of hazard category of the object using the developed scales evaluating the impact on the environment from the design of industrial facilities (table. 3 (for atmosphere) [8, 9].

Table 3. *Grading scale chemical exposure of projected industrial facilities*

The interval of changes of index values	**The level of impact**	**The name of the category of danger of the object**
Atmosphere		
$0 < I_1 \le 0,37$	Allowable	Safe
$0,37 < I_1 \le 0,45$	Conditionally valid	Few hazardous
$0,45 < I_1 \le 0,66$	Inadmissible	Middle hazard
$0,66 < I_1 \le 0,93$		Hazardous
$0,93 < I_1 \le 1$		Particularly dangerous

Integrated environmental hazard index of the projected industrial facility was developed for summarizing evaluation of environmental impacts (2):

$$I = \max \{I_1, \dots I_i, \dots I_n\}, \quad (2)$$

where I – environmental hazard index of the projected industrial facility; I_i – index evaluating for the *i*-th type of the impact of an industrial facility on the environment, dimensionless.

The algorithm was developed to determine the environmental risk assessment in the case of anthropogenic impact on the implementation of the projected industrial facility:

- quantitative indicators should be calculated for the evaluation of impacts on environmental components using the pre-research, process design and active normative documents;
- need to recalculate the values of the quantitative assessment of the impact on components of the environment in the indexes;
- decision is made on the admissibility of the project design for the index value of a component of the environment;
- environmental risk is calculated and determined its level of acceptability provided for each component of the project and the environment as a whole;
- set the level of anthropogenic impact of the facility on the ecological system in the value of environmental risk.

Mathematical formulas were proposed for determining environmental risk industrial facility of the projected according to the concept of EIA.

For the calculation of environmental risks method of the "index - risk" was modified [10].

The modification was carried towards establishing a functional dependence between developed system of indices and normalized levels of environmental risk in the form of probability methods using nonlinear regression. Mathematical formulas were developed to determine environmental risks presented in Table 4 [8, 9].

Table 4. *The formulas for calculating the environmental risk*

Environmental risks	Mathema-tical depen-dence	Output information
Integral environmental risk	$R_E = \sum_{i=1}^{m} r_i$	
Environmental risk	$r_i = a_i \cdot e^{b_i \cdot I_i}$	a, b – constants: $a_1 = 5,17 \cdot 10^{-9}$, $b_1 = 11,29$ (atmosphere); $a_2 = 4,84 \cdot 10^{-13}$, $b_2 = 21,01$ (surface water); $a_3 = 6,083 \cdot 10^{-8}$, $b_3 = 5,48$ (soil); $a_4 = 1 \cdot 10^{-6}$, $b_4 = -37,05$ (noise); $a_5 = 8 \cdot 10^{-10}$, $b_5 = 7,67$ (infrasound); $a_6 = 1 \cdot 10^{-8}$, $b_6 = 6,89$ (ultrasound); $a_{7,8} = 1 \cdot 10^{-8}$, $b_{7,8} = 4,95$ (electromagnetic impact, vibration); $a_9 = 2,47 \cdot 10^{-9}$, $b_9 = 8,93$ (radiation exposure).

An evaluation of environmental risks and anthropogenic impact is carried out according to the proposed scale taking into account normal levels established risks for Ukraine (Table 5).

Table 5. *Classification of risk levels*

Level	Risk r_i
Unacceptable	$>10^{-6}$
Conditionally acceptable	$10^{-6} – 10^{-7}$
Acceptable	$10^{-7} – 10^{-8}$
Definitely acceptable	$< 10^{-8}$

Next, decision is made on the admissibility of the introduction of an industrial facility in the industrial ecological system based on levels of anthropogenic load.

Therefore, the author proposes an approach to evaluating anthropogenic impact by identifying environmental risks introducing an industrial facility in the industrial ecological system based on the calculation of indices. Determining the value of environmental risk allows you to control the level of anthropogenic impact and focus not only on human health but also on other environmental impact.

The approach of anthropogenic impact assessment approved for the project of Alchevsk Steel Mill reconstruction.

The goal of the reconstruction of the Alchevsk Steel Mill is building a new industrial platform, thus revealed adverse effects on the environment. Such impacts associated with the occurrence of violations of various negative conditions and cleanliness of air, surface water, soil and others.

The main priority pollutants released into the air are nitrogen dioxide, carbon monoxide, methane. Pollution of surface waters of two rivers nearby is direct and indirect receivers wastewater facility. It was conducted soil testing to evaluation the current condition of soil were found soil contaminants such as arsenic, mercury, zinc, copper, chromium, manganese, barium, strontium, cadmium. The noise sources were found (technological equipment, smoke exhausts, fans, etc.).

Assessment of anthropogenic load of project of reconstruction Alchevsk Steel Mill on the environment is done by using the developed computational dependencies environmental risks (table. 6).

Table 6. *The evaluation of anthropogenic load of the project of reconstruction Alchevsk Steel Mill*

Component of the environment		Atmosphere	Surface water	Soil
Qualitative composition		CH_4,NO_2, CO	pH, O_2, biochemical oxygen demand, chemical oxygen demand, dry residue, chlorides, sulfates, nitrates, nitrites, phosphates, iron	Pb, Zn, Cu, Cr, Mn, Ba, Sr, ets
Index estimates	Indices	I_1=0,75	I_2=0,4	I_3=1
	Environmental risks	$r_1=2{,}5\cdot10^{-6}$	$r_2=2{,}2\cdot10^{-9}$	$r_3=1{,}5\cdot10^{-5}$
Level of impact		Inadmissible	Allowable	Inadmissible
Level of risk		Unacceptable	Acceptable	Unacceptable
Total evaluation index of environmental safety				
I=1 Inadmissible			*$R_E=1{,}75\cdot10^{-5}$ Unacceptable*	

Object parameters were established such as the level of risk that is unacceptable and the level of impact that is inadmissible.

The results of this assessment suggest that there is an excess concentration of certain pollutants in ambient air, surface water, and soil.

Program complex RISK_OVNS was designed to simplify the calculations of index parameters of environmental safety. Program complex RISK_OVNS provides a constant assessment of environmental conditions and environmental components designed for use in the operating systems Microsoft Windows XP, implemented in the programming language Delphi. Program complex RISK_OVNS has a comfortable intuitive interface that facilitates the process of determining the level of risk; automate work with databases, issue results of calculation of estimates of environmental safety in the form of informative, convenient reports. The main windows of program complex are depicted in fig.1. - fig.4.

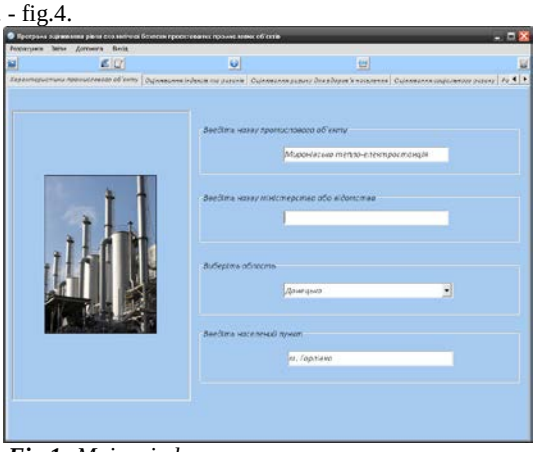

Fig.1. *Main window*

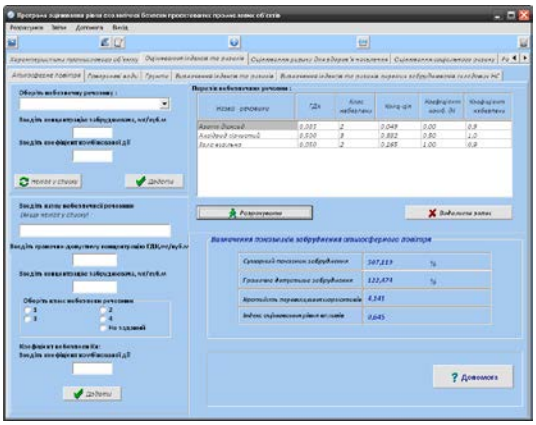

Fig.2. *Window evaluation of the of environmental safety projected industrial facilities - tab "Atmosphere"*

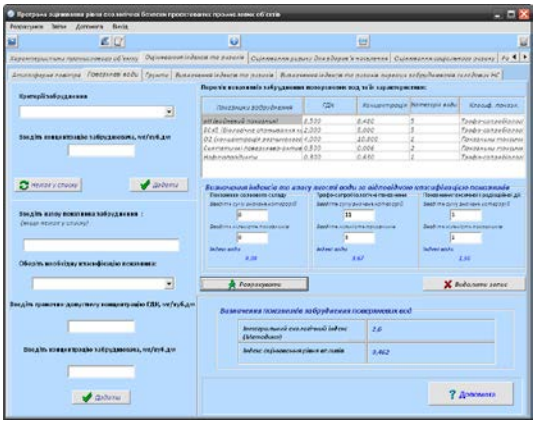

Fig.3. *Window evaluation of the of environmental safety projected industrial facilities - tab "Surface water"*

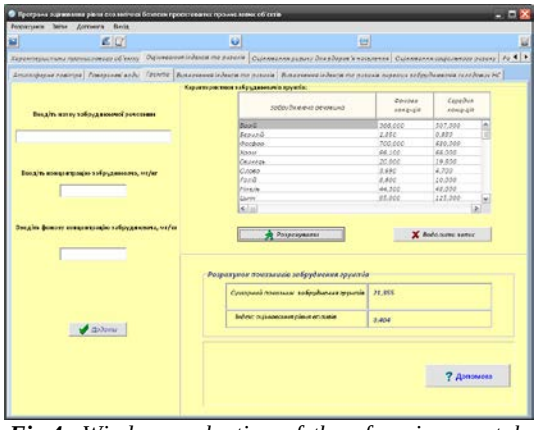

Fig.4. *Window evaluation of the of environmental safety projected industrial facilities - tab "Soil"*

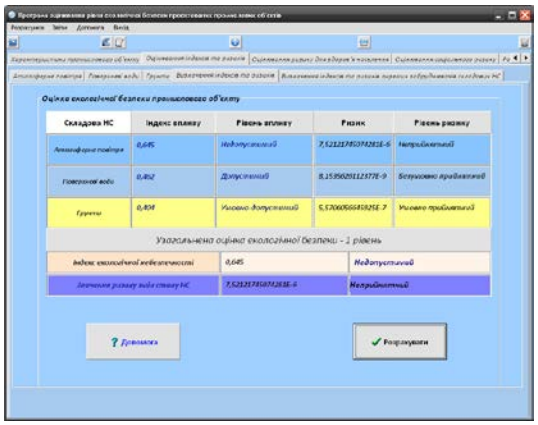

Fig.5. *Window evaluation indexes of environmental safety - Tab "Defining the indices and risks"*

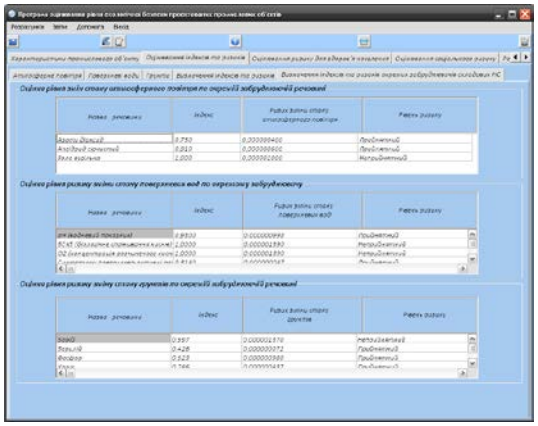

Fig.6. *Window evaluation indexes of environmental safety - Tab "Defining the indices and risks of certain pollutants elements of the environment"*

Thus, the developed program complex allows the evaluation of the environmental safety of the projected industrial facility.

4. Conclusion

The mathematical dependences have been proposed to determine environmental risks as an integral criterion for estimating anthropogenic impact for the purpose of controlling the level of environmental safety at the design stage of any industrial facility.

It was developed a method of forming index impact assessments of individual components of the environment and generally based on desirability functions.

The universal dimensionless index evaluations of environmental hazard impacts on the environment were built.

Mathematical dependences have been developed definition of environmental risk for the individual components of the environment and overall implementation of the planned industrial facility in the industrial ecological system that lets you identify dangerous threats in the design phase of industrial facilities.

The approach to the assessment of anthropogenic impact on the ecosystem enables you to take into account the chemical and physical influences from such an object by calculating the environmental risk.

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