Comprehensive assessment of level of environmental safety in city in construction of industrial and civil facilities

A G Dolgopolova, N K Plugotarenko

Department of Technosphere Security and Chemistry, Southern Federal University, 105/42 B. Sadovaya st., Rostov-on-Don 344090, Russia

E-mail: dolgopolova_anna@rambler.ru

Abstract. This work is devoted to the development of methods for a comprehensive assessment of the level of environmental safety in the city in the construction of industrial and civil facilities. The main methods of complex assessment of the influence of negative factors on the environment of cities and public health are considered. A logical-probabilistic model for assessing the level of environmental safety of the city in the construction of industrial and civil facilities has been developed, and it also makes it possible to make a forecast of the city's ecological development when operating a finished facility. This will help to formulate and calculate the effectiveness of ongoing environmental activities to reduce environmental risks.

1. Introduction

Every person wants to make his life the most comfortable and protected, but in real life the threat to the safety and comfortable existence of a person can come from an unfavorable state of the environment. The main threat is the health risk. At present, there is no doubt that environmental pollution has an impact on the emergence of a number of environmentally-related diseases, and also leads to a reduction in the average life expectancy of people exposed to environmentally unfavorable factors [1].

The ecological situation of the environment under study directly depends on a number of factors, including geographical location, relief features, the state of affairs in the industrial sector of the economy, and environmental literacy and responsibility of managers and specialists of enterprises and city institutions.

The problem of environmental protection and its restoration is becoming one of the most important tasks of mankind, the aggravation of which is stimulated by the ever-increasing rates of industrial development in all countries of the world. At the same time, a significant role is played by the construction phase. Already during the construction phase, it is necessary to have an idea of the location of the facility, its impact on the state of the environment and, subsequently, on the health of the population when operating the construction site in normal mode, as well as in the event of emergency conditions [2].

The methodology for making decisions relating to all types of human activity must be based on an analysis of risks, both existing and possible. Then the security of society and the environment will be determined by the degree of protection from the totality of all possible risks. In this case, the level of safety for the system under investigation is determined by the ecological challenge, which consists of the impacts of such subsystems as the soil cover, water bodies, air environment, noise pollution,

radiation situation. Currently, only a comprehensive risk analysis is an effective way of assessing the level of environmental safety, both individual objects and regions.

The lack of data on the extent and nature of environmental pollution in the construction and subsequent operation of industrial facilities weakens the attention of the city administration to taking effective measures to reduce pollution from man-made sources of environmental impact and sanitary and hygienic measures to protect the public. Therefore, the issue of forecasting the development of settlements during civil construction works and during the further operation of these facilities is topical, and carrying out a comprehensive assessment of the level of environmental safety opens the door to practical solutions to many problems in protecting the natural environment.

2. Materials and Methods

The main objective of the integrated assessment of the impact of negative factors of industrial cities on the state of the environment is to assess the possible changes in environmental quality through the impact of natural and anthropogenic factors associated with an increase in the number of objects under construction.

The main methods for a comprehensive assessment of the impact of negative factors on the state of the environment are:

- a method for determining the Hakanson Ecological Risk Index [3];
- fuzzy stochastic approach to modeling for integrated risk assessment of groundwater pollution [4];
- application of computational simulation models of radiation and noise propagation and dispersion of air pollutants to create a noise map and emission concentrations [5, 6];
- application of the integrated approach with the theory of fuzzy sets and the Monte Carlo method for modeling uncertainty in industrial safety risk assessments [7];
- application of the analytical hierarchy method for assessing the ecological quality of the environment in Laizhou Bay [8];
- method for assessing the vulnerability of the atmospheric environment associated with human exposure [9];
- conducting strategic environmental assessment and spatial analysis for mapping environmental sensitivity [10];
- application of the method of fuzzy complex assessment to determine the evaluation of the effectiveness of activities in the areas of health, safety and the environment [11];
- application of the estimation method based on the theory of catastrophes to form an assessment of the sustainable use of water resources in cities [12];
- the operational control of the state of objects in the technosphere and the environment based on the integration of data warehousing technologies, OLAP and expert systems [13];
- application of the Markov model, taking into account the uncertainty of the data for assessing industrial environmental efficiency [14].
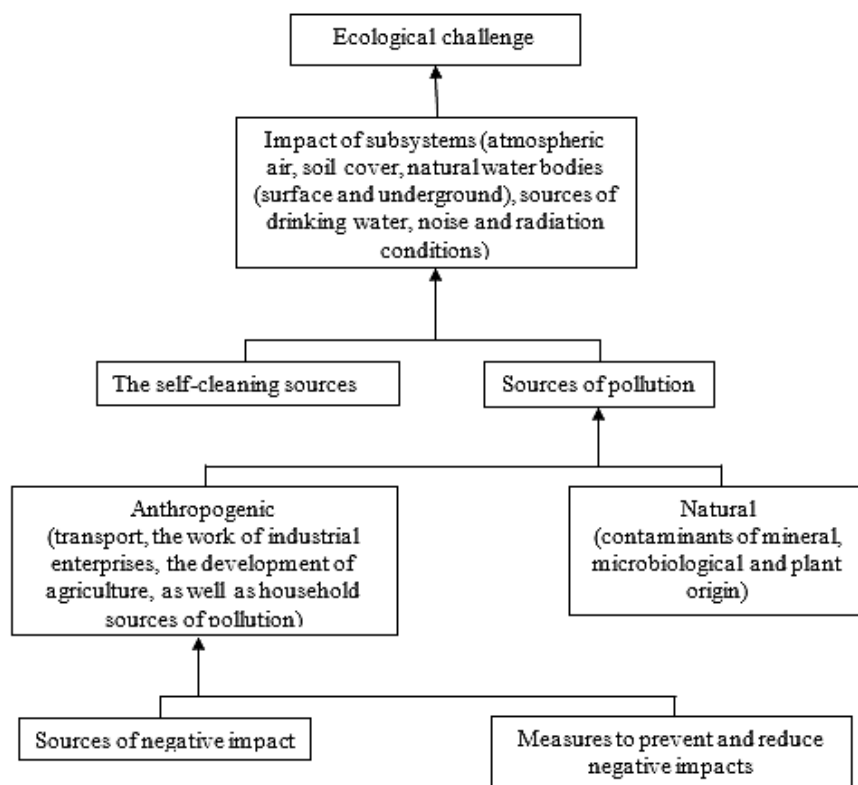
Thus, as a result of the analysis of existing methods of integrated assessment of the impact of negative factors of developing cities on the state of the environment, a lack of methods for quantitative safety assessment based on the concept of environmental risk has been established. And this is when there is already a successful experience in solving such topical problems based on logical-probabilistic modeling in risk management and efficiency of structurally complex technical, social and economic systems [15-20]. That is why the logical-probabilistic approach is chosen as the main research method in the work, allowing to evaluate the impact of both negative and positive factors on the environment, and to determine the significance of each of them in order to justify rational proposals for their parrying.

3. Results and Discussion

To ensure a safe life, it is necessary to understand that we exist in the system "man - habitat", where under the habitat we mean the environment of both natural and anthropogenic origin. At the same time, any human actions, as well as all components of the environment, are, first of all, technical means and technologies that, in addition to positive properties and results, have the ability to carry traumatic and harmful factors.

Thus, it is possible to recognize the inevitability of the existence of danger as a phenomenon indicating the possibility of the impact of any adverse factors on a person. Based on this, a comprehensive assessment of the negative impact is determined by the risk of damage to human health or life. Damage is the result or measure of a change in an object that makes it less suitable for use for its intended purpose. In turn, the potential danger with a specific form and way of manifestation is a threat. An environmental challenge is a threat that requires a response to reduce risk.

The safety of society and the environment is determined by the degree of protection from the totality of all possible risks - both existing and possible. In this case, the level of safety for the system under investigation is determined by the ecological challenge, which consists of the impacts of such subsystems as soil cover, natural water bodies, drinking water conditions, air environment, noise pollution, radiation situation. The general scheme of the approach to the development of the logical-probabilistic model is shown in Figure 1.

Figure 1. Scheme of the approach to the development of the logical-probabilistic model.

When considering the sources of pollution of each of the subsystems, it is also necessary to take into account the effect of the self-cleaning sources of the subsystem in question. Sources of environmental pollution are subdivided into sources of natural and anthropogenic origin.

Natural sources include pollutants of mineral, microbiological and plant origin.

Anthropogenic sources of pollution for each of the subsystems under consideration include transport (automobile, river, sea, air and rail), the work of industrial enterprises (heat power, ferrous metallurgy, chemical, oil and oil refining, pulp and paper industry, engineering, metalworking, light, food industry, non-ferrous metallurgy), the development of agriculture (warehouses in which seeds are treated with pesticides, aerochemical treatment of crops, cattle, livestock and poultry houses, slaughterhouses, animal products processing (processing of hides, animal wastes, etc.), as well as household sources of pollution (solid domestic waste landfills, industrial waste landfills, authorized landfills, spontaneous dumps in unauthorized places, canned dumps, canned industrial landfills, other objects, including sludge accumulators, sludge accumulators, liquid and pasty waste storage tanks and other objects eniya waste belonging to the enterprise).

Anthropogenic sources of pollution will be considered as a set of negative impacts on the subsystem under investigation (emissions, discharges, emergencies in the operation of technogenic systems, etc.) and measures to prevent and reduce this negative impact (compliance with the sanitary protection zone, facilities, improving the quality of environmental measures activities, etc.).

Developing a logical-probabilistic model for assessing the level of environmental safety in an industrial city, it is necessary to take into account that the negative factors affecting one or another subsystem are added to each other or subjected to a logical disjunction operation – a logical "OR", since pollution of the subsystem can be influenced by either one from factors, and several at a time. A similar approach is applied to the evaluation of positive factors.

In turn, the impact of negative and positive factors on the subsystem under consideration will be multiplied or, in other words, subjected to a logical conjunction operation – logical "AND", since both pollution and measures to prevent and reduce this negative factor occur simultaneously and, so to speak, neutralizing each other.

Thus, a logical-probabilistic model was developed to assess the level of environmental safety of an industrial city.

4. Conclusions

In this paper, an algorithm is presented for constructing a model for a comprehensive assessment of the level of environmental safety in an industrial city using a logical-probabilistic approach. Such a model includes the impact of such environments as atmospheric air, soil cover, natural water bodies (surface and underground), sources of drinking water, noise and radiation conditions. The total number of elements in the developed model was 1355 units. Of these, 885 elements are factors that affect the state of the environment.

The practical implementation of such a model will allow us to assess not only the influence of various factors when directly carrying out construction works on the state of the environment, but also to formulate a forecast of the impact on the environment during operation of the finished object both in normal mode and in cases of an emergency situation. This will help to formulate and calculate the effectiveness of ongoing environmental activities to reduce environmental risks.

References

[1] Kowarsch M and Jabbour J 2017 Solution-oriented global environmental assessments: Opportunities and challenges *Environmental Science & Policy* **77** pp 187–192

[2] Poluyan L V, Syutkina E V and Guryev E S 2017 Software Systems for Prediction and Immediate Assessment of Emergency Situations on Municipalities Territories *IOP Conf. Series: Materials Science and Engineering* **262** 012199 doi:10.1088/1757-899X/262/1/012199

[3] Jiang X, Lu W X, Zhao H Q, Yang Q C and Yang Z P 2014 Potential ecological risk assessment and prediction of soil heavy-metal pollution around coal gangue dump *Natural Hazards and Earth System Sciences* **14** pp 1599–1610

[4] Li J, Huangb G H, Zengc G, Maqsoodd I and Huange Y 2007 An integrated fuzzy-stochastic modeling approach for risk assessment of groundwater contamination *Journal of Environmental Management* **82** pp 173–188

[5] Silva L T and Mendes J 2012 City Noise-Air: An environmental quality index for cities *Sustainable Cities and Society* **4** pp 1–11

[6] Silva L T 2015 Environmental quality health index for cities *Habitat International* **45** pp 29–35

[7] Arunraj N S, Mandal S, Maiti J 2013 Modeling uncertainty in risk assessment: An integrated approachwith fuzzy set theory and Monte Carlo simulation *Accident Analysis and Prevention* **55** pp 242–255

[8] Song D, Gao Z, Zhang H, Xu F, Zheng X, Ai J, Hu X, Huanga G and Zhangn H 2017 GIS-based health assessment of the marine ecosystem in Laizhou Bay, China *Marine Pollution Bulletin* **125** pp 242–249

[9] Zhang Y, Shen J, Ding F, Li Y and He L 2016 Vulnerability assessment of atmospheric environment driven byhuman impacts *Science of the Total Environment* **571**, pp 778–790

[10] Ainhoa González Del Campo 2017 Mapping environmental sensitivity: A systematic online approach to supportenvironmental assessment and planning *Environmental Impact Assessment Review* **66** pp 86–98

[11] Li W, Liang W, Zhang, L and Tang Q 2015 Performance assessment system of health, safety and environmentbased on experts' weights and fuzzy comprehensive evaluation *Journal of Loss Prevention in the Process Industries* **35** pp. 95–103

[12] Chena Y, Zhang S, Zhang Y, Xu L, Qu Z, Song G and Zhan J 2017 Comprehensive assessment and hierarchical management of the sustainable utilization of urban water resources based on catastrophe theory *Journal of the Taiwan Institute of Chemical Engineers* **60** pp 430–437

[13] Penkova T G, Korobko A V, Nicheporchuk V V and Nozhenkova L F 2014 On-line modelling and assessment of the state of technosphere and environment objects based on monitoring data *Procedia Computer Science* **35** pp 156–165

[14] Shokravi S, Smith A and Burvill C R 2014 Industrial environmental performance evaluation: A Markov-basedmodel considering data uncertainty *Environmental Modelling & Software* **60** pp 1–17

[15] Burnell L J., Horvitz E J 1993 A Synthesis of Logical and Probabilistic Reasoning for Program Understanding and Debugging *Uncertainty in Artificial Intelligence Proceedings of the Ninth Conference* pp 285–291

[16] Geng X, Ouyang D, Zhao X and Hao S 2016 Probabilistic logical approach for testing diagnosability of stochastic discrete event systems *Engineering Applications of Artificial Intelligence* **53** pp 53–61

[17] Boyko A I, Novitsky A V, Banny A Aand Kondratyuk A V 2013 Logical and probabilistic model evaluating the reliability of agricultural machines *Engineering – From Theory to Practice: a collection of articles on materials of the XXIX International scientific-practical conference* **12** pp 149–156

[18] Solojentsev E D 2007 Scenario logic and probabilistic risk models bribes *Proceedings of the VII International Conference "Managing large systems"* pp 87–90

[19] Hunter A 2013 A probabilistic approach to modelling uncertain logical arguments *International Journal of Approximate Reasoning* **53 (1)** pp 53–61

[20] Liu W, Yue K and Gao M 2011 Constructing probabilistic graphical model from predicate formulas for fusing logical and probabilistic knowledge *Information Sciences* **181 (18)** pp 3828–45