Methodical approach to assessing the level of environmental safety of urbanized territories

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Abstract. The article presents a methodological approach to combining three criteria reflecting the ecological, economic and social characteristics of an urbanized territory. In particular, attention is paid to the third stage of the methodical approach to assessing the level of environmental safety of urbanised territories. Its essence lies in the construction of a spatial diagram of a comprehensive assessment, in the three-dimensional space of which values are plotted in the form of points characterising the complex state of the environment of the considered sections of the urbanized territory. The scientific approach proposed by us and the corresponding improved method for assessing the level of environmental safety of urbanised territories will, in our opinion, allow, even at the stage of pre-project surveys, to make environmentally effective, economical and socially responsible decisions related to changes in the infrastructure of urbanised territories during the reconstruction and redevelopment of existing and construction of new urban facilities. At the next stage of the study, we plan to pay attention to the peculiarities of the negative impact on the environment of specific objects of modern infrastructure of urbanised territories, namely production facilities of certain hazard classes and shopping and entertainment centres or complexes located on sites that were previously allocated for the placement and operation of enterprises.

1 Introduction

Our previous studies [1-3] allow us to conclude that when assessing the level of environmental safety of objects of modern infrastructure of urbanised territories, it is necessary to take into account social, environmental, and economic conditions, as well as a number of restrictions. We have also previously studied the features of the negative impact on the environment of modern infrastructure facilities in large cities and analysed existing methods for assessing the level of environmental safety of urbanised territories [4-6]. Based on the research performed, we have started the third stage of improving the method for assessing the level of environmental safety of urbanised territories. Its substance lies in the construction of a spatial diagram of a comprehensive assessment, in the three-dimensional space of which values are plotted in the form of points characterizing the complex state of the environment of the considered sections of the urbanised territory.

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2 Materials and methods

At the first stage of the study, we mathematically described three criteria reflecting the ecological, economic and social characteristics of the urbanised territory. We have reduced each of them to the corresponding indicators by converting them into dimensionless ones with an interval from 0 (the best state) to 1 (the worst state).

At the second stage, we compared each of the environmental indicators of industrial and economic functional zones of urbanised territories with acceptable values for environmental, economic and social characteristics. At the same time, we used a graphical description of relative indicators in the form of planar diagrams of the most significant characteristics (environmental, economic and social) of the studied objects of the corresponding functional zones. Graphical representation of research results by means of diagrams, graphs, and so on is an integral part of modern scientific research in technical and ecological-economic directions.

The third stage consists in the formation of a comprehensive assessment of the environmental safety of urbanized territories, which seems to be the most important task of combining the obtained Pi indicators into an integral assessment. We proposed to solve this problem on the basis of constructing a spatial diagram of a comprehensive assessment, in the three-dimensional space of which values are plotted in the form of points characterising the complex state of the environment of the considered sections of the urbanized territory (hereinafter - industrial and economic zones), primarily in terms of environmental, but also in terms of economic and social indicators. The general appearance and structure of such a spatial diagram are shown in Figure 1.

The basis for comparing each of the indicators P_i of the environmental state of urbanised territories with acceptable values of $P_i(add)$, we use the approach mentioned in [7-10] to determine the ecological and economic efficiency (EEE) of various products and production processes. This approach is based on the assessment of the state of the environment, possible impacts on human health and ecosystems, as well as material and financial costs in the organisation of technological processes for the production of products throughout its life cycle. It is based on the scientific works of Peter Saling, Andreas Kicherer, Brigitte Dittrich-Kramer, David R. Shonnard, Isabell Schmidt, Manfred Meurer and others [8-10], according to which the term “eco-efficiency” was coined by scientist Stephan Schmidheiny and his colleagues and subsequently approved by the Business Council for Sustainable Development (WBCSD) in his 1992 publication [11]. Initially, it was based on the concept of creating more goods and services while using fewer resources and creating less waste and pollution. At the same time, by “eco-efficiency” Peter Saling, Andreas Kicherer and others understand the ecological optimisation of systems as a whole, taking into account economic factors, namely the ratio of economic growth to the results of negative impact on the environment.

In our research, by analogy with products or production processes, functional zones of an urbanised territory are used for consideration within the framework of a methodical approach to determine ecological and economic efficiency. The formation of a comprehensive assessment of the environmental safety of urbanised territories seems to be the most important task of combining the obtained P_i indicators into an integral assessment. We proposed to solve this problem on the basis of constructing a spatial diagram of a comprehensive assessment, in the three-dimensional space of which it is possible to apply a value (to depict a point) characterising the complex state of the environment of the considered section of the urbanised territory, primarily by ecological, but also by economic and social indicators (see Figure 1). Graphical representation of research results by means of diagrams, including spatial ones, graphs, etc. It is an integral part of modern scientific research in the technical, ecological, and economic fields [12-13].

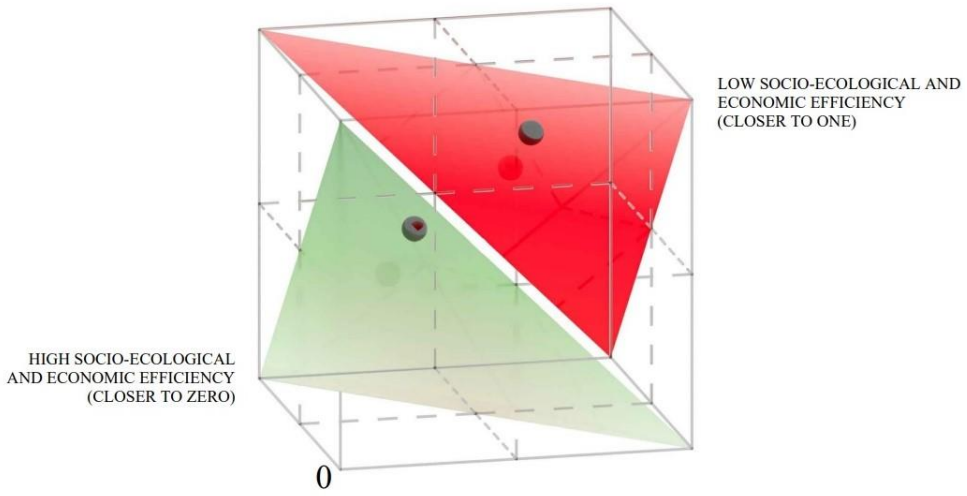

Fig. 1. An example of a spatial diagram of a comprehensive assessment of the condition of an urbanised area under study with the designation of acceptable value zones.

The coordinate grid of this spatial diagram has been compiled by us in such a way that the 0Y axis characterises the value of the environmental indicator, the 0X axis, the values of the economic indicator, and the 0Z axis, the value of the social indicator. Thus, if the points plotted in the spatial diagram according to the values of the P_i indicators (ecological P_{ecol}, economic P_{econ}, and social P_{soc}) turn out to be close to the beginning of the coordinate grid, then they will characterise the most favourable condition of the considered section of the urbanised territory, primarily as environmentally safe. Conversely, if the points turn out to be close to the upper right corner of the spatial diagram, they will characterise the most unfavourable condition of the considered section of the urbanised territory, primarily as environmentally unsafe.

The described scientific principles allow us to scientifically substantiate and improve the methodology for assessing the level of environmental safety of urbanised territories, which, along with the environmental characteristics of the state of the surrounding urban environment, will also take into account the economic and social indicators of the development of the studied territories, or their individual sections, both for the current situation and for the future when making various design decisions.

3 Results

As a result of the completed stages of research, we described changes in the infrastructure of urbanised territories, which led us to the formation of residential, social and cultural, and economic zones in the former industrial territories. In turn, it caused the need to revise the existing methods of assessing the level of environmental safety of urbanised territories and propose new scientific principles for their improvement, which would take into account the features of the negative impact on the environment of modern urban infrastructure facilities, including those located in the economic zones of urbanised territories.

We decided to make the principle of supplementing economic and social characteristics with ecological ones the basis for improving the methodology for assessing the level of environmental safety of urbanised territories. Due to the fact that the sustainable development of urbanised territories is based on ecological, social and economic aspects

[14-16] and one of the key goals of the UN sustainable development is to ensure the openness, security, resilience and environmental sustainability of cities and settlements, in the procedure for a comprehensive assessment of the level of environmental safety of urbanised territories, we have included the definition of ecological K_{ecol}, economic K_{econ}, and the social K_{soc} criteria.

The subsequent unification of the above-mentioned criteria into a complex (integral) assessment was carried out sequentially in three stages, namely, through the transformation of the K_i criteria into the corresponding P_i indicators (environmental $P_{ecol,}$ economic P_{econ} , and social P_{soc}), having a single range of possible values; comparison of each of the P_i indicators with its maximum permissible value $P_i(add)$, and unification P_i into a single comprehensive assessment of the environmental safety of urbanised territories.

The normative spatial diagram was constructed as part of the implementation of the first stage [3]. In turn, comparative spatial diagrams of the factorial assessment of the state of the environment of industrial and economic zones are devoted to research in the framework of the second stage of improving the method for assessing the level of environmental safety of urbanised territories.

The spatial diagram of the factorial assessment of the state of the environment of an industrial zone of an urbanised territory clearly shows that a typical industrial zone, as a rule, has the highest value of an economic indicator, but reduced social and environmental indicators. This is due to the significant economic effect of enterprises for the region with a controversial impact on the socio-demographic sphere and a negative impact on the environmental components of adjacent territories.

At the same time, it is important to note that only the value of the social, environmental, and economic indicators of the studied territory below the limits of acceptable values (up to 0.37 on the normative spatial diagram) is strategically effective. In other cases, it is possible to discuss the uneven functional development of the territory, which for an industrial zone of an urbanised territory consists in its high efficiency from an economic point of view with unfavourable environmental and social indicators, which is an example of irrational use of the territory in the long term.

In turn, the spatial diagram of the factorial assessment of the state of the environment of the economic zone of the urbanised territory, presented at the previous stages, illustrates the typical values of environmental, economic and social indicators of shopping and entertainment complexes and centres as the most significant infrastructure objects of this zone. Therefore, it can be seen that with sufficiently effective social and economic indicators, the environmental indicator is above the limit of acceptable values, which makes shopping malls similar to industrial facilities in terms of a complex negative impact on the environmental components of adjacent territories.

Figure 1, as it was mentioned above, shows an example of a spatial diagram of a comprehensive assessment of the condition of an urbanised area under study, in the three-dimensional space of which values in the form of balls are plotted that characterise the complex state of the environment of the sites under consideration, primarily in terms of environmental but also economic and social indicators. In our opinion, it is advisable for further research to use this type of spatial diagram to determine the position of the infrastructure of industrial and economic zones in it, with further comparison of their positions relative to each other and the planes of unfavourable and favourable zones.

4 Discussion

The stages of the study described above, in our opinion, are sufficient grounds for confirming the stated goal, namely, the need to revise existing methods for assessing the level of environmental safety of urbanised territories and propose new scientific principles

for their improvement, which would take into account the features of the negative impact on the environment of modern urban infrastructure.

The proposed approach of combining three criteria reflecting the ecological, economic, and social characteristics of an urbanised territory is supplemented by an illustration in the form of Figure 1 and its detailed description.

At the first stage, we translated each of the three criteria into the corresponding indicators in such a way that each of them was transformed into a dimensionless one with an interval from 0 (the best state) to 1 (the worst state). Comparison of each of the environmental indicators of urbanised territories with acceptable values was carried out by us at the second stage, where we considered the corresponding functional zones of the urbanized territory as an object of research. At the same time, we used a graphical description of relative indicators in the form of planar diagrams of the most significant characteristics (environmental, economic, and social) of the studied objects of the corresponding functional zones. As for the third stage of the study, we visually present a comprehensive assessment of the environmental safety of urbanised territories in the form of a spatial diagram, in the three-dimensional space of which values are plotted in the form of dots characterising the complex state of the environment of the considered sections of the urbanised territory according to environmental, economic and social indicators.

In the future, at the next stages of the study, we plan to continue the improved method in order to ensure the possibility of its practical probation.

5 Conclusions

Thus, the basic scientific principles are obtained that allow us to scientifically substantiate and improve the method for assessing the level of environmental safety of urbanised territories, which, along with the environmental characteristics of the state of the surrounding urban environment, will also take into account the economic and social indicators of the development of the studied territories, or their individual sections, both for the current situation and for the future when developing

The scientific approach proposed by us and the corresponding improved method for assessing the level of environmental safety of urbanised territories will, in our opinion, allow, even at the stage of pre-project surveys, to make environmentally effective, economical, and socially responsible decisions related to changes in the infrastructure of urbanised territories during the reconstruction and redevelopment of existing and construction of new urban facilities.

At the next stage of the study, it is planned to pay attention to the peculiarities of the negative impact on the environment of specific objects of modern infrastructure of urbanised territories. To do this, we selected production facilities of certain hazard classes, as well as shopping malls or complexes located in the former “inner” zones of large cities [1-2] on sites that were previously allocated for the placement and operation of enterprises.

In the future, our improved methodological approach to assessing the level of environmental safety of urbanised territories may be particularly in demand in the process of preparing design solutions for new urbanised infrastructure facilities for various purposes in the structure of existing urbanised territories, including shopping malls or complexes and adjacent landscaping.

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