

**GeoTerrace-2020-039****The research of the impact of environmental factors on the use of underground real estate**

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**SUMMARY**

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The formation and development of Ukrainian cities are one of the most important tasks in the development of the innovation potential of the regions on the basis of increasing their attractiveness to residents by reducing the environmental impact of underground real estate use. Given the views of scientists on solving the problems of environmental factors of underground real estate use, it should be noted the lack of clear solutions and integrated approaches. The application of mathematical methods and models for the study of the influence of environmental factors on the use of underground real estate lands within the framework of an integrated approach will allow us to determine the standardized indicator and give appropriate recommendations. The purpose of the study is to quantify the impact of environmental factors on the use of the underground real estate.

## Introduction

Currently, in large cities there are conditions under which the use of underground real estate is not always taken into account the impact of environmental factors, and therefore it is necessary to improve methodological approaches to taking into account environmental factors in its assessment. One of the essential aspects of consumer characteristics of underground real estate in the settlements of Ukraine is ecological, which often goes unnoticed by researchers, appraisers and land users. We should also mention the weak information resource for environmental assessment, as well as the lack of effective technical, legal and economic levers that ensure monitoring and improving the efficiency of underground land use of cities. All the above reasons reduce the environmental characteristics of the underground real estate and its importance in the urban environment (Lykhohrud, 2000; Law of Ukraine, 2011). However, the objective circumstances associated with the difficult environmental situation and the growing importance of the development of underground real estate use emphasize the relevance of the study.

The formation and development of Ukrainian cities is one of the most important tasks in the development of the innovation potential of the regions on the basis of increasing their attractiveness to residents by reducing the environmental impact of underground real estate use. Given the views of scientists on solving the problems of environmental factors of underground real estate use, it should be noted the lack of clear solutions and integrated approaches. In their scientific works, scientists (Danylyshyn, 2008, p. 256; Lykhohrud, 2000) focused on the environmental factors of land use in settlements, studied the legislative aspects of regulating the impact of environmental indicators and information support of environmental monitoring of land use at the regional level. In this direction, the research of scientists (Williamson, 1997; Ho et al., 2013), who highlighted the influence of environmental factors in determining the value of real estate, deserves attention. On the basis of their developments, the existing methods of land and real estate valuation are oriented. In (Korniiets & Savenko, 2017; Van Oosterom, 2013), researchers identified the most important factors influencing the use of real estate lands of settlements, using mathematical and cartographic methods of their evaluation. The application of mathematical methods and models for the study of the influence of environmental factors on the use of underground real estate lands within the framework of an integrated approach will allow to determine the standardized indicator and give appropriate recommendations. The purpose of the study is to quantify the impact of environmental factors on the use of underground real estate. To achieve this goal, the following tasks are solved: 1) analysis of previous research in the field of research on the impact of environmental factors on the use of underground real estate; 2) development of an information basis for the implementation of the method of assessment of the integrated environmental indicator of underground real estate use; 3) determining the directions of development and implementation of the method of assessment of the integrated ecological indicator of underground real estate use; 4) carrying out a quantitative assessment of the impact of environmental factors on the use of underground real estate; 5) development of directions of application of the integrated indicator of ecological influence in the system of use of lands of underground real estate.

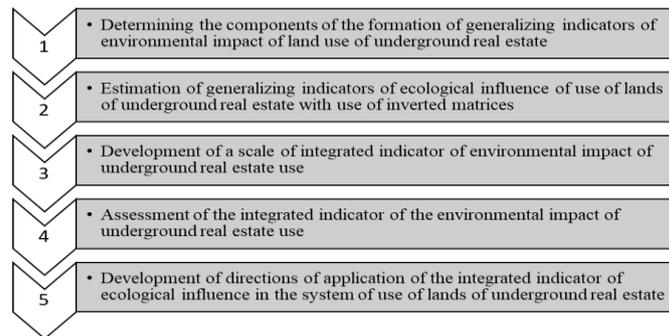
## Methods of investigation

To determine the ecological factor influencing the use of underground real estate  $E_{pn}$ , the choice of the system of ecological factors as a set of quality status of the natural environment  $E_{pn1}$ , acceptable norms of real estate  $E_{pn2}$  and anthropogenic impacts of underground real estate  $E_{pn3}$ . The generalizing indicator of a qualitative condition of a natural environment of ecological influence on use of the earths of underground real estate was formed taking into account indicators (Korniiets et al., 2017; Pieri et al., 1996): the condition of the soil of the site of the underground real estate; the state of the surface layer of air in the area of the underground real estate; the degree of landscaping of the territory of the underground real estate; condition of water bodies located in the area of the underground real estate object; availability of forest resources in the area of underground real estate.

The generalized indicator of admissible norms of use of objects of underground real estate was formed at the expense of indicators: noise impact on the space of the underground real estate object; pollution and gassiness of the location of the underground real estate object; soil deformations of the location of the underground real estate object; erosion of soil processes on the surface of the underground real estate; dangers of landslides on the land plot of underground real estate; qualitative characteristics of air in the voids of the soil of the underground real estate.

The development of a method and models for assessing the integrated environmental indicator of underground real estate use was carried out on the basis of stages: 1) determining the components of the formation of generalizing indicators of environmental impact of underground real estate use; 2) assessment of generalized indicators of ecological impact of underground real estate use with the use of inverse matrices. 3) development of a scale of integrated indicator of environmental impact of underground real estate use. 4) assessment of the integrated indicator of environmental impact of underground real estate use. 5) development of directions of application of the integrated indicator of ecological influence in the system of use of lands of underground real estate.

The scheme of realization of a method of an estimation of an integrated ecological indicator of use of the earths of underground real estate is presented on Figure 1.



**Figure 1** Scheme of implementation of the method of estimation of the integrated ecological indicator of underground real estate use

Within the framework of the proposed method, the components of the formation of generalizing indicators of the ecological impact of the use of underground real estate lands are determined (1-3, 6). An inverse matrix model was used to assess the general indicators of the environmental impact of underground real estate use. For this purpose, a corresponding matrix of its components is constructed for each generalizing indicator. The general form of the matrix was as follows:

$$A_{E_{pni}} = \begin{pmatrix} 1 & E_{pni1}/E_{pni2} & E_{pni1}/E_{pni3} & E_{pni1}/E_{pni4} & E_{pni1}/E_{pni5} \\ E_{pni2}/E_{pni1} & 1 & E_{pni2}/E_{pni3} & E_{pni2}/E_{pni4} & E_{pni2}/E_{pni5} \\ E_{pni3}/E_{pni1} & E_{pni3}/E_{pni2} & 1 & E_{pni3}/E_{pni4} & E_{pni3}/E_{pni5} \\ E_{pni4}/E_{pni1} & E_{pni4}/E_{pni2} & E_{pni4}/E_{pni3} & 1 & E_{pni4}/E_{pni5} \\ E_{pni5}/E_{pni1} & E_{pni5}/E_{pni2} & E_{pni5}/E_{pni3} & E_{pni5}/E_{pni4} & 1 \end{pmatrix}, \quad (1)$$

According to the constructed matrix for unification of indicators, taking into account their mutual influence and assessment of generalizing indicators of ecological impact of underground real estate use, an inverted matrix was built, which had the form:

$$1/A_{E_{pni}} = \begin{pmatrix} 1 & 1/E_{pni1}/E_{pni2} & 1/E_{pni1}/E_{pni3} & 1/E_{pni1}/E_{pni4} & 1/E_{pni1}/E_{pni5} \\ 1/E_{pni2}/E_{pni1} & 1 & 1/E_{pni2}/E_{pni3} & 1/E_{pni2}/E_{pni4} & 1/E_{pni2}/E_{pni5} \\ 1/E_{pni3}/E_{pni1} & 1/E_{pni3}/E_{pni2} & 1 & 1/E_{pni3}/E_{pni4} & 1/E_{pni3}/E_{pni5} \\ 1/E_{pni4}/E_{pni1} & 1/E_{pni4}/E_{pni2} & 1/E_{pni4}/E_{pni3} & 1 & 1/E_{pni4}/E_{pni5} \\ 1/E_{pni5}/E_{pni1} & 1/E_{pni5}/E_{pni2} & 1/E_{pni5}/E_{pni3} & 1/E_{pni5}/E_{pni4} & 1 \end{pmatrix}, \quad (2)$$

## Results of investigations

The results of the assessment of the generalized indicators of the ecological impact of the use of underground real estate lands are presented in Table 1. To determine the environmental impact on the use of underground real estate, it is proposed to develop a scale of an integrated indicator of the environmental impact of underground real estate use (Table 2).

**Table 1** The results of the assessment of generalized indicators of the environmental impact of underground real estate use

Summary indicator	Value
$E_{pn1}$	2.11
$E_{pn2}$	3.03
$E_{pn3}$	4.86

**Table 2** Scale of the integrated indicator of ecological impact of underground real estate use

The value of the integrated indicator, relative units	The level of influence of the integrated indicator
0	Missing
0.01 – 1	Minor
1.01 – 2	Low
2.01 – 3	Insignificant
3.01 – 4	Moderate
4.01 – 5	Essential
5.01 – 6	Influential
6.01 - 7	Considerable
7.01 - 8	High
8.01 - 9	Much high
9.01 - 10 and above	Absolute

Based on the assessment of generalizing indicators, a model of the integrated indicator of the ecological impact of the use of underground real estate lands  $E_{pn}$  was developed, relative units:  $E_{pn} = (E_{pn1} * E_{pn2} * E_{pn3})^{1/3}$  (3). According to the developed model, the value of the integrated indicator of the ecological impact of the use of underground real estate land  $E_{pn}$ , which is 3.14. Regarding the scale of the integrated indicator of the environmental impact of underground real estate use, the value obtained corresponds to a moderate level, which indicates a very serious impact of environmental factors on land use and location of underground real estate. Development of directions of application of the integrated indicator of ecological influence in system of use of the earths of underground real estate provides along with the account of town-planning, spatial and investment factors, increase of the following indicators: quality of the natural environment of ecological impact on the use of underground real estate; permissible norms for the use of underground real estate; anthropogenic environmental impacts of underground real estate use.

## Conclusions

Thus, as a result of the research the previous experience in the field of researches of influence of ecological factors on use of lands of underground real estate is analyzed, the basic problems and prospects of modern use of underground space for building of big cities are defined. The information basis for realization of a method of an estimation of an integrated ecological indicator of use of the earths of underground real estate on the basis of an estimation of components of formation of generalizing indicators of influence on use of underground real estate is developed. The method of estimation of the integrated ecological indicator of underground real estate land use is implemented, which allowed to carry out a quantitative assessment of the influence of ecological factors on the use of underground real estate lands. According to the results of the method, the value of the integrated indicator of the environmental impact of underground real estate use is obtained, which corresponds to a moderate level, which indicates a very serious impact of environmental factors on land use and

location of underground real estate. The proposed areas of application of the integrated indicator of environmental impact in the system of underground real estate use, which include, taking into account urban, spatial and investment factors, improving the quality of the environment in terms of environmental impact on the use of underground real estate, allowable use of underground real estate, anthropogenic environmental impacts of underground real estate use.

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