Using the results of environmental monitoring for economic calculations on the example of adjusting the cost of land plots using the indicative method

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Abstract. The purpose of the work is to compare the ranges of the cadastral value of land plots with the environmental situation in these territories. The issue is considered on the example of the impact of polycyclic aromatic hydrocarbons (PAH) on industrial-urbanized territories adjacent to two enterprises, one of which is located in Moscow (a waste incineration plant), the other in the Moscow region (a plant producing metal products, Podolsk). The assessment of the toxic impact of biologically available PAHs on these territories was carried out using a new indicative method developed by the author. A feature of this method is taking into account not only the concentration of pollutants in the objects under study, but also the physicochemical and toxicological properties of each compound. The results of the study, presented in cartographic form, were compared for the first time with maps of the cadastral value of land plots located in the studied territories. The comparison showed that the price of land plots in most cases is not proportional to the level of toxic effects of polycyclic aromatic hydrocarbons, that is, the environmental component was not taken into account when forming their cost. However, the obvious connection between chemical pollution of territories and economic damage (including damage to the health of the population living in polluted territories) gives reason to propose a way to correct the cadastral value by dividing it by a correction factor that reflects the degree of contamination of the territory with compounds of the PAH group and represents the equivalent of the concentration of one of the most toxic polycyclic aromatic hydrocarbons, benzo(a)pyrene, the impact of which on humans and the environment corresponds to a similar total impact of PAHs contained in the soil of a particular territory.

1. Introduction

In the modern world, there are many urgent problems of both theoretical and applied nature, the solution of which requires the involvement of specialists from various fields of activity. Often such problems and tasks are characterized by global dimensions, but more and more often there is a tendency towards interdisciplinary work on smaller (geographically) issues, which, nevertheless, can be extremely important within a single country or region. Ecological and economic issues are also among such issues, which is explained by the following reasons. On the one hand, any man-made impact on the environment entails one or another economic damage, becomes the cause of a decrease in the quality and quantity of natural resources. On the other hand, the elimination and prevention of the consequences of such an impact requires significant financial investments, and, consequently, a quantitative assessment of the damage caused to the environment and the population living in areas...
subject to negative technogenic impacts, in particular, chemical pollution. For example, the thesis of Professor V.V. Vershinin, in which the author, from the point of view of land management economics, considered the issue of the consequences of pollution of agricultural land with heavy metals [1].

Another group of the most dangerous toxicants, which are especially common in industrialized urban areas, are polycyclic aromatic hydrocarbons (PAHs). Some of them are considered supertoxicants, for example, benzo(a)pyrene. Due to their low reactivity and almost ubiquitous distribution, compounds of this group accumulate in environmental objects, from where they can enter the human body with food, through the respiratory tract or through the skin upon direct contact with a contaminated object. Incorporating into DNA chains during replication, the molecules of these compounds lead to errors in this process and cause the formation of cancer cells or mutations [2]. Obviously, this causes serious damage to human health, which is currently considered to be one of the subspecies of the country's capital. This means that an increase in the incidence of the population adversely affects the economy of the state and it is highly desirable to prevent such impacts, and if this is not possible, to develop effective mechanisms to compensate for their consequences. In practice, one almost always has to deal with the second option, since it is not possible to ban the use of vehicles (which are the main source of PAH emissions), stop the operation of thermal power plants, waste incineration plants and other industrial enterprises that also generate PAHs in the course of their activities, or transfer them to a safe distance from residential areas. One of the ways to compensate for damage to health can be the introduction of a correction factor into the cadastral value of residential land plots, which would allow taking into account the environmental situation in the given territory.

2. Materials and methods

The purpose of this study is to analyze the compliance of the cadastral value of land plots in some districts of Moscow and the Moscow region with the level of technogenic impact of PAHs on the territory of these districts. Territories within a radius of 5 km from the waste incineration plant SUE "Spetsзавod No. 3" (Moscow, South Administrative District) and from the industrial zone, including the plant for the production of metal products NPO "Luch" (Moscow region, Podolsk) were chosen as the objects of study. To achieve this goal, a new indicative method for assessing the level of toxic effects of PAHs on industrially urbanized territories was developed; a geoeconomic assessment of the selected territories was carried out using this method; the results obtained are presented in a cartographic form and compared with the map of the cadastral value of the corresponding land plots.

To assess the level of toxic effects of PAHs, soil samples were taken at a distance of 0.2; 0.5; one; 1.5; 2; 3; 4 and 5 km from the above enterprises in each of the four main directions. The selection was made by the "envelope" method in accordance with [3]. Sample preparation and measurement of the concentration of 12 out of 16 priority PAHs in the samples was carried out according to the method MUK 4.1.1062-01 [4], which was modified by the author (acetonitrile was used for extraction, and the qualitative identification of compounds was carried out not by the total ion current, but by isolated ions).

However, as was shown in previous publications with the participation of the author, neither the content of benzo(a)pyrene, nor the total concentration of PAHs fully reflect the objective situation with the toxic effects of these compounds on the territory. Taking into account the physicochemical and toxicological features of each detected representative of this group allows the index of the total toxic effect of biologically available PAHs (I), proposed by the author and numerically corresponding to the concentration of benzo(a)pyrene in the soil, the effect of which is equivalent to the total effect of all PAHs taken into account in the analysis [5].

Presentation of the results of the study in a cartographic form was carried out using the "Surfer 9" software.
3. Results
When comparing the results of zoning with the cadastral maps of the studied territories [6], it can be seen that lands located in zones with different levels of toxic effects in some cases have the same range of value, which seems illogical (figures 1–4).

Figure 1. Levels of the general toxic impact of PAHs on the territory within a radius of 5 km from NPO "Luch".

Figure 2. Cadastral valuation of land plots per 1 m² on the territory within a radius of 5 km from NPO "Luch" [6].

Figure 3. Levels of the general toxic impact of PAHs on the territory within a radius of 5 km from the State Unitary Enterprise "Spetszavod No. 3".
Thus, the data obtained as a result of monitoring carried out according to the scheme proposed by the author can be used to adjust the cost of land plots, taking into account the degree of environmental pollution in a particular area.

4. Discussion
For each industrial-urbanized territory, assigned to one or another group according to the types of permitted use, its own pricing factors have been established, such as distance from the city center, accessibility of various infrastructure components, land area, etc. [7].

There are no environmental factors in the assessment of land, which in the end often leads to the establishment of equal prices for plots with significantly different degrees of pollution. To date, there are several proposals for calculating the environmental safety of urban areas, but in practice these indicators are used extremely rarely [8].

In our opinion, the environmental component of the cost of a land plot can be taken into account by introducing a coefficient that is inversely proportional to the level of technogenic impact, which, in turn, is quantified by the index of the general toxic impact:

\[ C = \frac{C_{cad}}{I_{rel}} \]  

Where \( C \) is the cadastral value of the land plot, taking into account the environmental situation, rub./m\(^2\); \( C_{cad} \) - the cadastral value of the land plot, established as a result of the standard procedure for the state cadastral valuation, rub./m\(^2\); \( I_{rel} \) is the relative index of the total toxic effect of biologically available PAHs on the territory of the land plot (the ratio of the current index to the calculated maximum allowable).

For example, land plots, one of which at the time of sale is characterized by a pollution level \( I_{rel} = 1.2 \), and the other \( I_{rel} = 0.8 \), all other things being equal, should have a different value - in the first case, a high value of \( I_{rel} \) should reduce the cost of the site by 20% relative to the cost established in the manner prescribed by Federal Law No. 237 "On State Cadastral Valuation" [9], and in the second, a lower value of this indicator - to increase the cost by the same amount.

If the territory of the assessed site is made up of areas with different values of the index I, then the correction factor can be calculated as the sum of the indices, taking into account the share of the territory with each value of I from the total area of the site, taken as 1 (or 100%), according to the formula (2):
\[ I_{rel} = \sum_{n=1}^{m} I_n \cdot S_n \]  

(2)

Where \( I_n \) is the relative index on the n-th share of the area under assessment; \( S_n \) is the proportion of the territory with a relative index \( I_n \) of the total area of the assessed site; \( m \) is the number of shares that make up the estimated area, with different relative indices \( I_n \).

For example, if the relative index for 30% of the area of the land plot is \( I_1 = 0.8 \), and for the remaining 70% of the area the value of the index \( I_2 = 1.2 \), then the correction factor will be:

\[ I_{rel} = 0.8 \cdot 0.3 + 1.2 \cdot 0.7 = 1.08 \]  

(3)

As a result, if a potential buyer is an individual purchasing permanent housing, then he will have a choice - either to purchase a cheaper option with a less favorable environmental situation and receive regular compensation payments for living in this territory [10] or to live in the territory, characterized by the best environmental performance, but pay extra for the implementation of measures to maintain a favorable environment.

If the buyer is a legal entity, and the acquired territory is intended for economic activity, then the relatively cheap, but polluted territory will also require the owner to pay either for reclamation or for a higher pollution fee. At the same time, the acquisition of initially more expensive land will reduce the above costs. Thus, taking into account the environmental component through the indices of the general toxic impact when assessing the cadastral value, in conjunction with the implementation of mandatory measures to compensate or reduce the harmful technogenic impact, will improve the quality of polluted territories with the functioning of a rather flexible land market.

5. Conclusion

In the course of the study, on the example of two territories within a radius of 5 km from industrial enterprises in Moscow and the Moscow region, it was shown that the cadastral value of land plots located on these areas is not proportional to the level of impact of polyaromatic hydrocarbons on these territories, which, in our opinion, is a serious shortcoming of the modern mechanism for calculating the cadastral value. According to the author, this mechanism must necessarily include an environmental component, which can be represented by a coefficient expressed through the index of the total toxic effect of biologically available polyaromatic hydrocarbons. This will allow, on the one hand, to compensate for the damage to the health of people living in polluted areas (by reducing the cost of polluted areas), and on the other hand, to attract capital to finance environmental protection measures (due to a proportional increase in the cost of land that is less susceptible to toxic effects).

The results presented in this study concern only one group of ecotoxics. Due to the significant difference in the physicochemical, toxicological and other properties of PAHs with other groups of pollutants, the latter were not considered in this work, although, of course, there is a need for an environmental assessment of industrial-urbanized areas and their levels, with subsequent adjustments to the cost land plots. This issue, along with the introduction of the proposals outlined in the article into the cadastral system, are the main directions for further work.

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