Criterion for Estimation of Ecological Safety of Objects of Urban Transport Construction

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Abstract. A new approach to assess the ecological safety of the urban environment including urban transport facilities is being considered. The chemical and acoustic pollution of the environment from the impact of the urban transport construction objects is analyzed. The description of the sustainable state concept and ecological balance of the urban environment is given. A criterion for assessing environmental safety based on a comprehensive indicator of the city's biosphere compatibility was proposed. The scale of environmental safety assessments is constructed.

Key words: Ecology; Ecological safety of the urban environment; Biosphere compatibility; Transport construction; Ecological balance; criterion for environmental safety assessing.

1. Introduction

The problem of environmental safety in construction and city economy is very relevant. In cities, human activities change the natural landscape and creates an artificial environment of life support [1].

The degradation of the environment affects not only the decline in overall quality of life of the population, but also on the pace of economic and social development of society. It primarily affects the human health.

The solution to the problem of conflict-free interaction of man and Nature only possible on the basis of an integrated approach to ensuring environmental safety of the urban environment.

2. Results and discussions

The article offers the model of an estimation of ecological safety of motor transport system in the form of an integral indicator. This figure takes into account the quantitative relationships between the actual parameters of the biosphere and the technosphere [2]. The value of the integral indicator of biosphere compatibility is presented in:

\[ \eta = \sum_k \sum_l \left( B_{ik} - Z_{ik} \right) \]

(1)
Where $B_k$ is a quantitative indicator of the state of the biosphere exposed to $k$ elements of road infrastructure; $Z_k$ is a quantitative indicator of the state of technosphere.

This figure is due to contaminants from road infrastructure.

The integral indicator is in the form of an index. It can be from zero (minimum) to one (maximum).

To assess the environmental safety of the urban environment proposes a criterion, which characterizes the chemical pollution of the territory from the impact of objects of municipal transport construction - $\eta_0$.

To assess the noise impact of items of urban transport construction is also proposed to use the coefficient of biosphere compatibility of the urban area – $\eta_N$ [3].

The proposed approach is the concept of ecologically safe state of the urban environment from the impacts of urban objects of transport construction [4].

The urban environment is a system open to external influences. These impacts translate the system to a new state.

Under the steady state of the urban environment from the impacts of transport construction should be understood that the condition in which the natural environment has the properties of self-healing, self-regulation and self-purification. These states of the urban environment are characterized by an ecological equilibrium – a dynamic steady state [5]. The potential of the biosphere more potential of technosphere: $B_k > Z_k$.

The complete ecological balance is maintained at the allowable anthropogenic and technogenic loads. In this case, the ecological situation can be considered favorable [6,7]. The level of anthropogenic impact (chemical pollution of atmospheric air emissions and the level of acoustic impact) will not exceed the allowable values minimum environmental standards and regulations.

If there is exceeding the permissible values of the minimum environmental requirements, it is possible to recognize a threat. This situation is characterized by the level of negative impact on the environment. This leads to negative changes in environmental quality. In such a situation, the urban area is part of the ecological balance [8,9]. The components of the natural environment are not restored fully.

Comfortable state – the state of the system, the parameters of which satisfy the balance equation components of the biosphere, noosphere and technosphere of the city [10,11]. Otherwise, there is degradation of the biosphere and a reduced quality of life of the urban population.

Balance sets a ratio of resources of the biosphere and technosphere of the city. It provides a complete environmental balance of the urban ecosystem [12,13].

A state that is simultaneously sustainable, equilibrium, balanced and comfortable is a state of ecological safety system.

Diagram of the state changes of the urban environment during the transformation of ecosystems and biosphere is shown in figure 1 (Figure 1.).

![Figure 1](image-url)
As criterion of an estimation of ecological safety of the urban transport is the construction of a minimum-length vector, which is defined as the difference of two vectors, having common origin [14].

Mathematically this condition can be written in the following form:

$$K = \min \rho = |\rho| = \frac{1}{n} \left| \sum_{i=1}^{n} (\rho_{Ti} - \rho_{Ci}) \right|^2$$

(2)

where $\rho_{T}$ and $\rho_{C}$ is the spatial coordinate vectors of the current and target States of the system; $n$ is the dimension of the vector space.

The target state of the objects of urban transport construction is provided as a result of control actions:

$$C_s = F(C; U \Omega; t)$$

(3)

where $C$ is the current state of the system; $U \Omega$ – control effects; $t$ – time.

If there are no control actions to achieve environmentally safe state, the system to get out of the region of allowable States.

The ratio of biospheric compatibility of the urban area can be used to determine the extent of contamination of the natural environment from the impacts of transport construction [15].

The main factors of the negative impact of road transport on the environment are chemical and noise pollution. The assessment of this impact can be represented by the sum of these two components [16,17].

Then, the total integral indicator of biospheric compatibility of the urbanized area will be:

$$\eta = k_1 \eta_p + k_2 \eta_n$$

(4)

where $k_1$ и $k_2$ weight coefficient which characterizes the degree of importance of the requirements for a particular site ($0 \leq k_i \leq 1$). Total sum of weight coefficients must be equal to one.

Depending on the obtained values of the integral indicator of biosphere compatibility is set to feature environmental conditions: favorable (there are positive changes), relatively benign (practically no impact), little favorable (minor impact), unfavorable (negative impact), very unfavorable (adverse effects).

To determine the boundary a value of ecological situations was used the generalized desirability function of Harrington [18-20] (Table 1).

**Table 1. Values of "desirability function" for estimation of ecological safety of objects of transport construction.**

| The desirability     | Mark on the scale of desirability | The environmental situation from the impacts of transport construction |
|----------------------|-----------------------------------|---------------------------------------------------------------|
| Very bad             | 0,00 – 0,20                       | very unfavorable                                             |
| Bad                  | 0,20 – 0,37                       | unfavorable                                                  |
| Satisfactory         | 0,37 – 0,63                       | little favorable                                             |
| Well                 | 0,63 – 0,80                       | relatively favorable                                         |
| Very good            | 0,80 – 1,00                       | favorable                                                   |

To determine the current state of the urban environment from the impacts of urban transportation facilities construction on the basis of ecological situation on the urbanized area adopted the scale of assessments of environmental safety (Figure 2.).
Figure 2. Grading scale ecological safety of urban environment from the impact of objects of urban transport construction.

The calculated values of the indicator of biosphere compatibility of the urban area and the identified state of the urban environment can be the basis for recommendations for the environmental reconstruction of the site.

3. Conclusion
So, the proposed criterion of ecological safety of the urban environment allows to analyze the impact of specific urban transport construction on the formation of the ecological situation. The criterion allows to quantify the urban environment. In the future it will help in the implementation of control actions to achieve environmentally safe condition.

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