Methodological Approaches in Determining Damage from Environmental Risks Generated by Transport Impacts

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Abstract. This article discusses the emerging risks from road transport, the nature of the impact of vehicles on the environment. The ranking of the specified total pollution index is given, which determines the need for actions to restore the natural environment. The calculation of environmental risk and damage caused by the roadside area by a number of heavy metals is presented.

1. Introduction
Currently, the transport impact on the components of the environment is gaining a leading position. It manifests itself in the form of negative impacts on the atmosphere, soils, surface and underground waters, and ecosystems of various levels of organization. In particular, this effect is manifested in the contact areas, characterized by various types of development of the territory [4].

When estimating the environmental safety of the road, the assessment of emerging risks is not a mandatory factor, but it can help optimize the technologies, materials used in the construction of roads, working methods for their arrangement and ways to reduce existing types of risk in order to create a healthy environment for workers, residents of nearby settlements and the environment [6].

Settlements, along which major highways go, agricultural lands, roadside service facilities (service stations, gas stations) are negatively affected by road transport.

With the "Transport strategy of Russia for the period till 2030", approved by order of the Government on November 22, 2008 №1734-r, motor vehicle emissions should be reduced by 60% (with a substantial increase in the fleet), due to the transition of road transport on the emission class of Euro 0, with transport included to a lower environmental class, for a long period of time will show the environmental risks along the roads.

It should be emphasized that recently the main emissions of heavy metals as copper, lead etc. occur from vehicles running on diesel fuel. At the same time, the quantity of freight traffic with the use of heavy transport today is growing rapidly [3]. Environmental risks emerging from road transport, according to the nature of the impact on people and the environment can be attributed to the continuous risks. The environmental targets can be both the staff of roadside service objects and population of the area (settlements along highways). It is a long action. It is not fatal; the impact is mostly remote in regards to affecting people, in rare cases, it can cause immediate reactions (individual intolerance of substances). It has a local and regional character in regards to environmental
dissemination; the duration depends on the type of substances and the time they take to decompose [2].

In previous studies, Chernyaeva I.V., Bershadskiy V.Ya., Mozgovoy R.V. revealed that the totality of substances alien to natural biogeocenoses, acoustic pollution from automobile transport are harmful to the environment and beyond the established roadside limits. The highest pollution indicators were obtained in the roadside zone of federal highways with a large traffic current, with insufficient organizational, technical and constructive solutions used to reduce the negative impact of traffic current and road facilities on road areas. The zone of exposure and influence of substances on the environment in some cases reaches 3000 m - Figure 1 [1,4].

Figure 1. Dissemination of road traffic impacts in a roadside area.

The nature of the impact of vehicles on the environment is direct, permanent and exploitation. At the same time, road structures have constant, wide coverage, direct and indirect environmental impacts.

2. Calculation of environmental risk from road transport

Thus, the environmental risks arising from road transport can be considered as a system that includes a source of danger and an object that this source affects. Using the theory of multiplication of probabilities, the probability of danger (P) depends on spatial (P_s) and time characteristics (P_t), is presented in formula (1).

\[ P = P_s \times P_t \]  \hspace{1cm} (1)

When danger arises after a certain event in the past has occurred, the full probability formula is used. The probability of danger (P) is determined taking into account the conditional probability of danger x when one or another event y occurs \( P(x/y) \) and the probability of the event (P_y) - formula (2).

\[ P = P(x/y) \times P_y \]  \hspace{1cm} (2)
where, \(P(\mathcal{Y}|\mathcal{X})\) – the conditional probability of danger \(x\) when the event \(y\) is committed; \(P_y\) is the probability of this event.

Risk cannot be assessed without analyzing the likely impact of the emerging hazard. Risk is a quantitative measure of danger taking into account its consequences, i.e. the resulting damage. The more damage that can be done, the higher the risk. Therefore, the risk can be defined as the product of the probability of the danger of an adverse event \(P\) and the expected damage \(Q\)-formula (3).

\[
P = P \times Q
\]

Risk is the dimension of the expected damage.

Environmental risk is an assessment of the objective possibility of the development of negative changes in the environment, or the adverse effects of these changes that arise over time due to negative environmental impacts [7,8,9].

Environmental risk is statistical, as it depends on both spatial and time characteristics of the environment, which are determined by many random factors.

So, by statistical environmental risk, we mean the risk that arises from the arbitrary determination of the place of economic activity, without analysis and objective environmental characteristics of the area in which this activity is planned, which will change in space and time. This case corresponds to economic activities carried out in roadside territories, where the choice of location is determined not by environmental factors, but by economic ones [5].

Let us define the damage \(-Q\), which is caused by the roadside area by a number of heavy metals from automobile transport, through the specified total pollution index \(Q = Z_y\). The objective possibility of an adverse event is the ratio of the number of points \(n_i\) to the total number of points \(N\) studied in the roadside territory, i.e. \(P_i = n_i / N\). Then the statistical environmental risk is determined by the expression (4):

\[
R = \sum_{i=1}^{m} P_i \times Z_i
\]

where \(Z_i\) – i gradation value.

Table 1. Ranking of the adjusted total pollution index [8].

| \(Z_y\) | Rank               |
|--------|--------------------|
| - 3 ≤ * < - 1 | Natural background |
| - 1 ≤ * < 0   | Technogenic background |
| 0 ≤ * ≤ 2    | Environmental norm |
| 2 < * ≤ 4    | Environmental risk |
| 4 < * ≤ 8    | Compensated crisis |
| 8 < * ≤ 16   | Uncompensated crisis |
| * ≥ 16       | Disaster           |

When deciding on the physical improvement of land using a complex of engineering and biotechnological measures, in order to restore roadside territories to meet environmental requirements, environmental rehabilitation is carried out. In this case, a methodology for assessing managerial risks in a given rehabilitation of territories is necessary. In this case, the damage \(Q\) is estimated by the costs of the rehabilitation of the selected site in rubles - formula (5).

\[
Q = q_{rub/year} \times S \times T
\]

where \(q_{rub/year}\) – costs in roubles for cleaning of 1 ha for the near-surface sediments per year, \(S\) – area to be cleaned, \(T\) - time of reduction of pollution from heavy metals to the sanitary state of soil in years.

The probability of danger is measured at the most contaminated gradation.

So, one of the most efficient and economical methods of cleaning soil from heavy metals is phytoremediation, which is biological purification method, based on the planting of some herbaceous
plants, which absorb excess concentration of heavy metals. To estimate the costs when using this technology in the areas of pollution the cost of planted herbaceous plants per hectare per year is calculated. Thus, for cleaning surface soil at very high-level pollution will require not more than 10 years. At the same time, throughout the whole phytoremediation period, it is necessary to perform ecological monitoring of the roadside environment, sampling and control over the areas.

3. Conclusions
We can make the following conclusions:

1) Today, the theory of risk is being intensively developed, but many fundamental provisions remain controversial. There is no unified definition of the concept of “risk”. You can often find the use of the term “risk” equivalent to the term “danger” or as a synonym for probability, the meaning of which is not identical.

2) We applied the risk theory to calculate the damage from transport impact in the roadside territories. The leading role of this type of technogenic impact on the components of the natural environment, which manifests itself in the form of the formation of ecological and geochemical anomalies with a high content of heavy metals, is emphasized. The main source of impact for the latter is heavy diesel-powered vehicles.

3) A methodology for calculating economic damage was developed using an updated total indicator of near-surface deposits. A system for ranking the environmental situation on the basis of this indicator is presented. The priority is given to the use of phytoremediation methods for the renovation of roadside territories and the elimination of environmental risks.

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