The impact of urban highways on roadside trees

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Abstract. The article describes the study of the impact of motor transport on green spaces along urban highways. The paper studies the process of necrosis that occurs on the leaves of trees. A full-scale experiment was conducted to determine the magnitude of damage to the leaves of trees. In conclusion, the most resistant tree species to the effects of pollutants are proposed.

1. Introduction
Most cities have a "green belt", that is, an autotrophic component (lawns, shrubs, trees, ponds, lakes, and the like). Urban forests and parks have aesthetic and recreational value and mitigate temperature fluctuations, reduce pollution and noise exposure, and are a habitat for birds and small animals.

An urban agglomeration is a powerful system that has all the surrounding world, all the components of the natural environment such as the atmosphere, vegetation, soil, terrain, groundwater and even climate [1].

The most important problems of the city that affect human health include air pollution by motor transport, industrial enterprises, thermal power plants and boiler houses, industrial and domestic water discharges, solid waste and their disposal, and others.

Voronezh is not among the cities affected by environmental disasters. At the same time, it is necessary to constantly monitor the rapidly changing environmental situation in order not to lose control of it.

A significant feature of air pollution in cities, especially large ones, is the exhaust gases of motor vehicles, which in a few capitals of the world, administrative centers of Russia and CIS countries, resort cities account for 60-80% of total emissions.

Vehicles emit more than 200 components into the air, including carbon monoxide, carbon dioxide, nitrogen and sulfur oxides, aldehydes, lead cadmium and a carcinogenic group of hydrocarbons (benzopyrene and benzanthrone). The greatest number of toxic substances emitted by motor transport into the air at low speed, at intersections, stopping at traffic lights at low speed the gasoline engine emits 0.05% hydrocarbons (of total emissions), and at low speed of 0.98%, carbon monoxide respectively to 5.1 % and 13.8% [2-7]. It is estimated that the average annual mileage of each car is 15-thousand km. On average, during this time, it depletes the atmosphere by 4350 kg of oxygen and saturates it with 3250 kg of carbon dioxide, 530 kg of carbon monoxide, 93 kg of hydrocarbons and 7 nitrogen oxides (table 1).
Table 1. Emissions of pollutants by various vehicles, g/km.

| Type of car | Engine type | Carbon dioxide | Hydrocarbons | Nitrogen oxides | Soot |
|-------------|-------------|----------------|--------------|-----------------|------|
| Passenger car | Internal combustion | 20 | 2 | 3 | 0.05 |
| Cargo | Internal combustion | 70 | 8 | 7 | 0.15 |
| Bus | Diesel | 10 | 3 | 6 | 1 |

2. Materials and methods

During the summer period of 2015 – 2016, an assessment was made of the state of tree plantations near the highway along Antonov-Ovseenko Street in the Northern micro district of Voronezh.

The type of vehicles and traffic congestion of the streets adjacent to the experimental sites were determined. The intensity of traffic congestion on the ring road on Antonov – Ovseenko Street was determined by the method of counting cars of different types 3 times a day at 10 o'clock, 14 o'clock and 19 o'clock. Cars were divided into categories with an internal combustion engine and with a diesel engine. Trucks with diesel engines were classified in the category of buses. Similarly, the sum of cars of each class was determined. The data were entered in the table "Traffic intensity". Based on the data obtained, the diagram "Traffic intensity on Antonov Ovseenko Street, Voronezh" was constructed (figure 1).

Next, the resulting number of cars, of different classes and with different types of engines. Based on the data obtained, the concentration of pollutants was obtained.

Three experimental sites were selected for the study. Site No. 1 car dogs along the street Antonov-Ovseenko. On the experimental site, 5 trees were selected: holly maple, pyramidal poplar, small-leaved elm, hanging birch. Site No. 2 was chosen in a draughty corridor between nine-story buildings located on Antonov-Ovseenko Street. On the experimental site, 5 experimental trees were selected: holly maple, pyramidal poplar, small-leaved elm, hanging birch. Site No. 3 was chosen in the courtyard of the house at 52 Antonov – Ovseenko Street. On the experimental site, 5 experimental trees were selected: holly maple, pyramidal poplar, small-leaved elm, hanging birch. The control site was investigated in the Railway district of Voronezh (Somovo village, Dachny Prospekt 67).

During the vegetative periods of 2015 and 2016, the condition of model trees was examined at the experimental sites. By eye assessment, the class of life stability is determined according to the table "Methods of sanitary and hygienic assessment, or life stability, of trees (according to B. G. Nesterov)" - table 2.
Table 2. Methods of sanitary and hygienic assessment, or life stability, of trees (according to B.G. Nesterov).

| Stability class | Characteristics of the state of trees |
|-----------------|---------------------------------------|
| First (I)       | The trees are perfectly healthy, with signs of good growth and development. |
| Second (II)     | Trees with a somewhat slow growth in height, with single dry branches in the crown and minor (10-15 cm²) external damage to the trunk, without the formation of rot. |
| Third (III)     | Trees are clearly weakened, with a disturbed crown, shortened shoots, pale color of needles in conifers, with the presence of hollows and stem rot, frost-breaking cracks with an area of more than 150 cm² with a stopped or weak increase in height, with a significant number of dry branches (up to 1/3 height) or dry tops. |
| Fourth (IV)     | Trees withering, with the presence of highly spread stem rot, fruit bodies on the trunks, in the crown up to 2/3 of dry branches, with large hollows and dry tops. |
| Fifth (V)       | Trees withered or with weak signs of viability, completely affected by stem rot and stem pests. |

In 2015, the percentage of leaf damage by necrosis (point, inter-peak, edge) was determined at the experimental sites of model trees by ocular assessment. In 2016, the percentage of leaf damage by necrosis (point, inter-peak, edge) was determined at the experimental sites of model trees by ocular assessment. In 2016, at the experimental sites, environmental pollution with dust was determined by its accumulation on the leaf blades of plants. During the study, 10 leaves were selected at each experimental site (at a height of 1.5-2 m). The dust was washed off the leaves with a brush into a pre-weighed evaporation cup, the water was evaporated, the cup with the dust was dried in a drying cabinet at a temperature of +105°C to a constant weight, and then weighed.

To determine the dust contamination per cm² of the leaf, the area of the leaf plates of the studied leaves was determined. To determine the area of the sheet plates, a conversion factor was set. The determination of the conversion factor is based on comparing the weight of a square of paper with a sheet of the same length and width. To do this, we took a piece of paper in a box and outlined a square equal to the length and width of this piece of paper, and then carefully outlined its contour [8,9]. Then the area of the cut square was calculated, and its weight, then the contour of the sheet was cut and weighed. Then calculations were made using formulas 1 and 2:

\[ K = \frac{S_n}{S_{kb}} \]  

\[ S_n = \frac{(R_n + S_n)}{P_{kb}} \]

where: K - the conversion factor, Sn - the area of the sheet, Skb – the area of a square of paper, Pkb – weight of a square of paper.

The conversion factor was calculated for eight leaves and the average value was derived. The length (A) and width (B) of each sheet were then measured.

The collection of leaves was started after the completion of their intensive growth. Samples were taken from plants that are in similar environmental conditions in terms of light and humidity. Medium-aged plants were used for the analysis. Leaf samples were taken from ten closely growing trees with 10 leaves each, a total of 100 leaves from one experimental site. The leaves were taken from the lower part of the crown, at the level of the raised hand, from the maximum available number of branches. Birch leaves were used only with shortened shoots. The leaves were taken about the same size, average for this species. Each sample was provided with a label indicating the date and place of collection.

In the measurements for measuring the collected material, we used: a ruler, a compass-meter, a protractor. With the left and right sides of each sheet were taken on five measurements: the width of the halves of the sheet (for measuring the sheet is folded transversely in half was applied top sheet to
the base, and then leaves unbent and formed on the fold were measured); the length of the second ribs of the second order from the base sheet; distance between bases of first and second veins of second order; the distance between the ends of the veins; the angle between the main vein and the second from the base of the vein of the second order.

The first four parameters were taken with a compass meter, the angle between the veins is measured by a protractor. When measuring the angle, the protractor was positioned so that the center of the base of the protractor window was at the site of the branch of the second vein of the second order. The value of asymmetry was estimated using an integral indicator - the value of the average relative difference per feature (the arithmetic means of the ratio of the difference to the sum of the sheet measurements on the left and right, attributed to the number of features).

In the first step, we find the relative difference between the values of the attribute on the left and on the right - (Y) for each attribute (to do this, find the difference in the values of measurements for one attribute for one sheet, then find the sum of the same values and divide the difference by the sum). Similar calculations are made for each attribute. The result is 5 Y values for a single sheet [10-16]. The same calculations are performed for each sheet separately. In the second step, we found the value of the average relative difference between the sides per feature for each sheet (Z). To do this, the sum of relative differences was divided by the number of features. Similar calculations were made for each sheet. In the third step, the average relative difference per feature for the sample (X) was calculated. To do this, all Z values were added and divided by the number of these values: where n is the number of Z values, i.e. the number of leaves. This indicator characterizes the degree of asymmetry of the body. For this indicator, a five-point scale of deviation from the norm has been developed, in which: 1 point is a conditional norm, and 5 points is a critical condition.

3. Results and Discussion

Based on the obtained data were used to determine the level of environmental pollution by emissions of motor transport. All substances supplied to the atmospheric air along Antonov-Ovseenko Street are carried by winds to the Northern micro district due to the direction of the wind rose. It should be noted that on the way of air masses there is a multi-story residential complex.

Of importance for the analysis is the degree of increase in leaf infection with necrosis. It is possible to trace its degree only in dynamics, over time. The results of the research are clearly demonstrated in figures 2 and 3.

![Figure 2. The degree of damage and necrosis at the road in June 2019.](image)

The diagrams clearly show the change in the degree of damage in different trees. The most dominant is marginal necrosis.
Thus, trees located between buildings under the influence of air masses are least susceptible to necrosis. The study showed the same results in different years.

4. Conclusion
The main result of the research is to determine the optimal type of trees for planting along highways. A visual comparison of the studied samples is shown in figure 4.

Based on the results obtained, the best option for green spaces near highways is birch. It is advisable to conduct further studies to determine the tree species least affected by highway emissions. Finding the optimal view will improve the ecology of the urban environment and highways, as well as make the roadside architecture visually more attractive.

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