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ASSESSMENT OF THE INFLUENCE OF THE INTENSITY OF TRAFFIC FLOWS ON THE STATE OF THE STREET AND ROAD NETWORK OF THE CITY

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ABSTRACT

The article is devoted to the assessment and forecasting of the level of atmospheric air pollution in street canyons in Kyiv by controlling the parameters of traffic flow. Today, road transport is the main anthropogenic source of environmental pollution. The specificity of air pollution by traffic flows lies in their ground location, close proximity to people's homes, which leads to the accumulation of pollutants near the ground surface - in the breathing zone of people.

The article analyzes the main approaches to modeling the dispersion of pollutants in the atmosphere from motor vehicles. It is advisable to assess the level of urban air pollution in homogeneous elements of the urban area - street canyons. Based on the urban street canyons model (OSPM), the level of pollution in the street canyons of the Pechersk district of Kyiv by the main harmful substances contained in car exhaust gases is determined. The critical intensity of traffic flows for each of the street canyons at which the level of pollution by the corresponding harmful substance reaches the maximum permissible value was determined.

Thus, the obtained results of the study allow us to quickly predict the level of air pollution in the roadside space of cities and prevent environmentally hazardous situations by controlling the parameters of the traffic flow.

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Introduction.

Today, road transport is the main anthropogenic source of environmental pollution. The increase in the intensity of traffic flows in certain local areas of the city, especially in the city center, leads to negative effects of various nature and mechanisms of environmental impact. There is a steady trend of inconsistency between the existing street and road networks of urbanized cities and the current level of traffic flows and, accordingly, the need for transport services, which leads to an even greater actualization of this problem [1].

The negative impact of road transport on ecosystems is as follows: reduced efficiency of the street and road network; consumption of natural resources, pollution of the atmosphere, soil, water bodies with harmful substances; heat release into the environment; creation of high levels of noise, vibration, electromagnetic radiation; injury and death of people, animals, material damage due to accidents; disturbance of soil and vegetation cover, etc.

The high density of emission sources and their diversity is a feature of urban air pollution. In this regard, in many cities, the concentration of pollutants significantly exceeds the maximum permissible values. The specificity of air pollution by traffic flows lies in their ground-based location, close proximity to people's homes, which leads to the accumulation of pollutants near the ground surface - in the breathing zone of people. The level of concentration of pollutants formed in the surface layer of the atmosphere has a spatial and temporal heterogeneity, which is explained by the following factors: intensity, composition of the traffic flow, meteorological conditions, geometric characteristics of the street and road network, terrain, presence of green spaces, regulated intersections, spatial orientation of the street, etc [2, 3].

Analysis of recent research and publications.

Assessment of the environmental state of the atmospheric air is carried out using mathematical modeling and field observations. Mathematical models that calculate pollutant emissions and their dispersion in the atmosphere allow not only to assess the level of air pollution, but also to predict the quality of air and determine strategies for reducing pollutant emissions. Today, many models of pollutant dispersion in the air cannot be used to quickly determine the concentration of pollutants in a city, as calculations require significant time. In addition, most models use significant spatial and temporal averaging when assessing the level of pollution, and do not take into account the microclimatic features of the city, terrain, etc. The main approaches to determining the level of air pollution from road transport are methods based on Gaussian models: CALINE-4 (California Line Source Model), Roadway 2.0, Hiway-2; GFLSM (General Finite Line Source Model), etc.; urban canyon models. The most common urban canyon models are STREET (Johnson et al., USA, 1973); Canyon Plum Box Model (Yamartino et al., 1986); Operational Street Pollution Model (Berkowicz, 1996) [4]. The OSPM model estimates the concentration of pollutants from traffic flows in street canyons, taking into account meteorological conditions, geometric characteristics of street canyons, and the model also takes into account mechanical turbulence created by vehicle movement [5].

The purpose of the study is to assess the impact of traffic on the environment within the functioning of the city's street and road network.

Results of the study.

To solve the problem of assessing the impact of traffic flows on the environment, namely the atmospheric air of Kyiv, the street and road network is represented by a set of elementary homogeneous street canyons, which are typical architectural and planning elements of the city and represent areas with buildings between the nearest intersections. The street and road network of the Pechersk district of Kyiv has 377 street canyons, for which spatial and geometric characteristics have been empirically established [6].

The main dynamic factors affecting the level of air pollution from traffic flows are traffic indicators, namely traffic intensity; traffic density; traffic speed; traffic composition; roadway loading level, etc. Management of traffic flow parameters allows predicting the quality of the state of atmospheric air and preventing critical situations in which the level of pollution exceeds the maximum permissible values [7].

Assessing the impact of traffic flows on the environment of urban road networks includes determining the intensity of pollutant emissions and the conditions for their dispersion.

Mileage emissions of pollutants by vehicles of the corresponding category were determined on the basis of the concept of "effective" traffic flow, which is a statistical aggregate of "effective" vehicles of the corresponding categories. An "efficient" vehicle of the corresponding category is a virtual vehicle, the technical and operational characteristics of which correspond to the weighted average characteristics of cars of all brands, models, series of cars belonging to this category, taking into account their weighting factors. The intensity of emissions of pollutants is determined on the basis of data on the daily dynamics of traffic characteristics, namely: intensity, density; speed of movement; composition of the traffic flow. The algorithm for determining the intensity of pollutant emissions from traffic flow is shown in Fig.1.

The assessment and forecasting of the level of air pollution in street canyons from traffic flows was carried out on the basis of the Operational Street Pollution Model, which is based on the Gaussian type of pollutant dispersion in combination with the characteristics of the street and road network of cities. According to this model, the concentration of pollutants is determined within the street canyon and is equal to the sum of the concentration of direct pollutant dispersion, the concentration caused by air recirculation in the street canyon and the urban background concentration.

The concentration of direct dispersion of pollutants from the traffic flow is equal:

$$C_d = \sqrt{\frac{2}{\pi}} \int \frac{L \cdot Q dx}{U_S W \sigma_Z(x)} \tag{1}$$

L - the length of the street canyon, m;
Q - the intensity of pollutant emissions from the "effective" traffic flow, mg/m*s;
Us - the wind speed at street level, m/s;
W - the width of the street canyon, m;
σ_z (x) - the parameter of vertical dispersion at a distance x from the emission source;

The recirculation zone is characterized by the inflow of pollutants from another part of the street canyon and is determined by the length of the turbulent vortex and the geometric parameters of the canyon. The concentration of pollutants from the recirculation of pollutants within the street canyon is determined as follows:

$$C_r = \frac{Q \cdot l_r}{W \cdot (\omega_t \cdot l_t + \omega_s \cdot l_s)} \tag{2}$$

l_r, l_t, l_s – the geometric characteristics of the recirculation zone;
ω_t, ω_s – the velocity of pollutant dispersion through the upper and side parts of the street canyon, respectively, m/s [8].

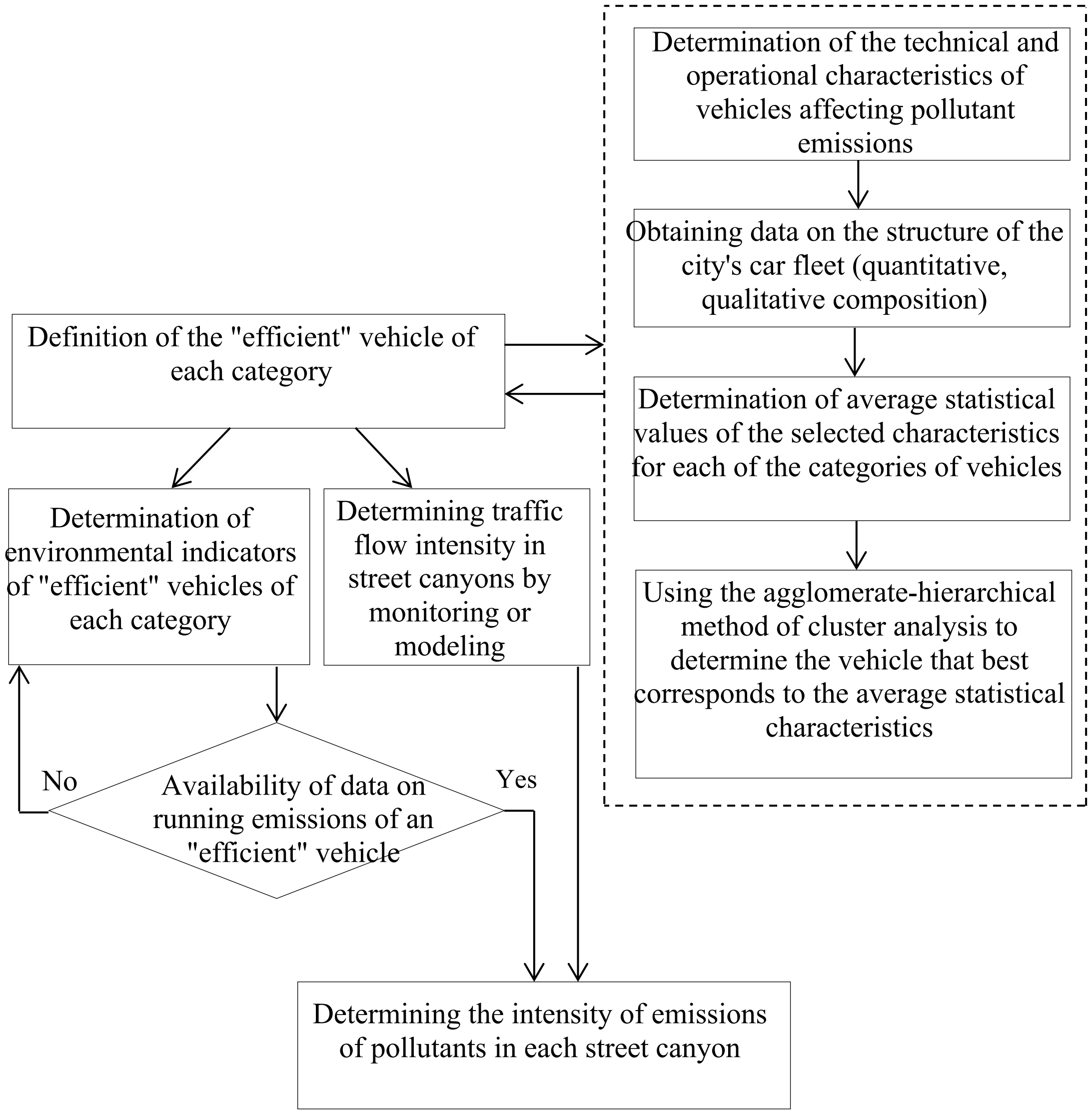

Figure 1. Algorithm for determining the intensity of emissions of polluting substances by the traffic flow

The dynamics of the emission intensity of the main pollutants and their concentration in one of the most typical street canyons (I. Mazepa Street) are shown in figures 2, 3.

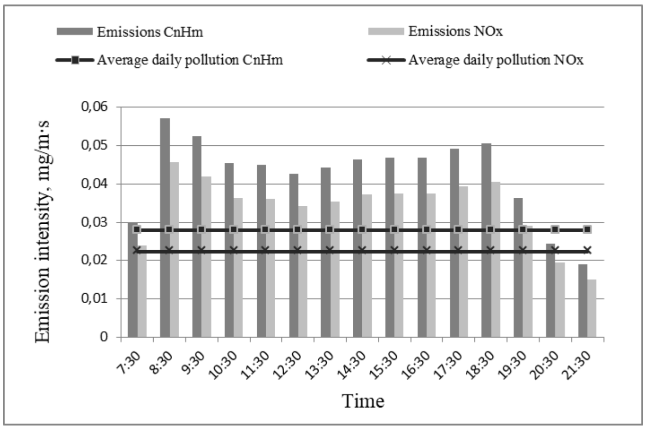

Figure 2. Dynamics of pollutant emission intensity.

Regulatory maximum allowable concentration (MAC) values are set for each pollutant. There are maximum one-time, average daily, and working area MACs. The main characteristic of the hazard of a harmful substance is the maximum single MAC, which is set to prevent reflex reactions of a person during short-term exposure (up to 20 minutes) to pollutants.

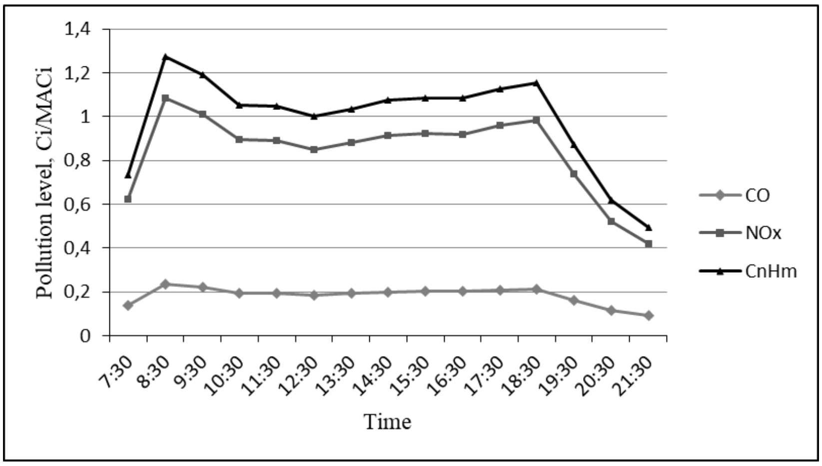

Figure 3. Dynamics of pollution levels at a wind velocity of 5 m/s.

In Fig. 4 shows the level of atmospheric air pollution in a street canyon depending on the wind speed at the roof level and the intensity of traffic flow. At a wind speed of 3 m/s and a traffic intensity of more than 0.4 vehicles per second, the concentration of nitrogen oxides will exceed the maximum permissible values; at a wind speed of 1 m/s, an excess of nitrogen oxides will be observed already at an intensity of 0.2 vehicles per second.

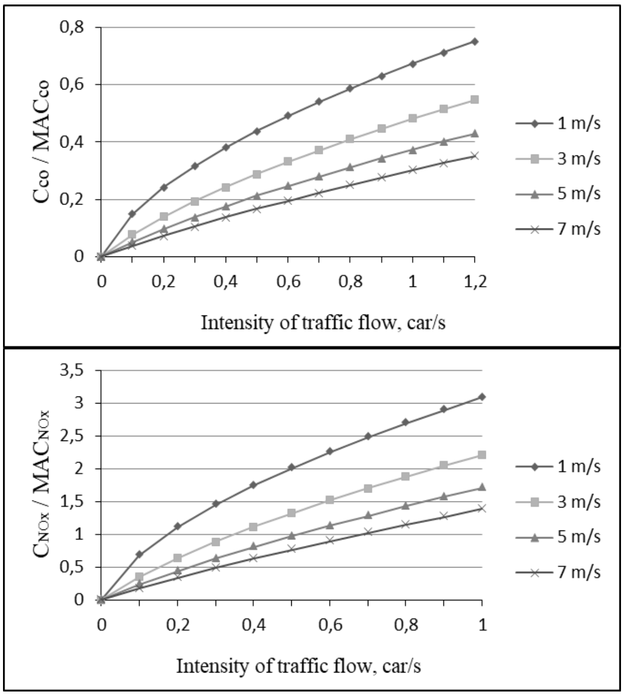

Figure 4. Pollution level at different wind velocity (I. Mazepa Street).

Since the city's street canyons have different spatial geometric characteristics: width, length, spatial orientation of the canyon, building solidity and composition (weighted average height of buildings, building density, average angle of buildings to the street axis), the level of pollution will differ in them, respectively, at the same traffic intensity and wind speed. In this regard, for each street canyon, the corresponding traffic intensities were established at which the level of pollution by the relevant harmful substance reaches the maximum permissible value (critical traffic intensities ($I_{кр}$)).

Table 1 shows for some street canyons of Kyiv the values of traffic flow intensities at different wind speeds when the NOx concentration reaches the maximum allowable values.

Thus, the determined values of the critical traffic intensity will allow us to quickly predict the level of atmospheric air pollution in the roadside space and, by controlling the parameters of the traffic flow, to prevent dangerous situations in which the level of pollution exceeds the standard values in a timely manner [9].

Table 1. The value of critical traffic flow intensities.

Street canyon	Critical intensities of traffic flows ($I_{кр}$), cars/s			
	1 m/s	3 m/s	5 m/s	7 m/s
1. Lipsky lane	0,1	0,21	0,31	0,42
2. Lipska street	0,095	0,2	0,3	0,39
3. Pylyp Orlyk street	0,115	0,24	0,355	0,47
…				

Fig. 5 shows the values of critical traffic intensities for I. Mazepa Street at different wind speeds. Thus, at a wind speed of 3 m/s, the maximum permissible concentration of pollutants is achieved at a traffic flow intensity of 0.29 vehicle/s for nitrogen oxides and 0.35 vehicle/s for hydrocarbons.

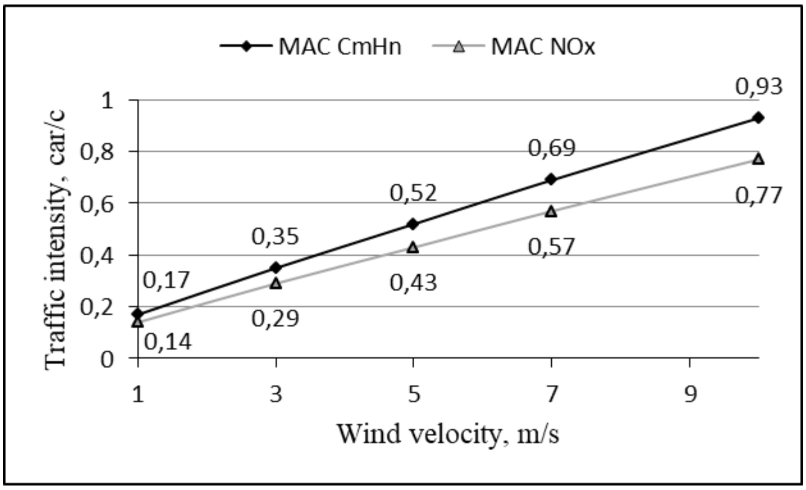

Figure 5. Critical values of traffic flow intensities (I. Mazepa Street).

Thus, the change in the concentration of the main pollutants was determined depending on the wind speed at the level of the roof of buildings (wind speed, which is determined by the global transfer of air masses and does not depend on the surface roughness) and the intensity of traffic flow.

Conclusion.

The main methods for assessing the level of urban air pollution by road transport are analyzed, including: dispersion models for individual highways, dispersion models in urban street canyons, and statistical models for predicting concentrations. Based on the urban street canyon model (OSPM), the level of pollution in the street canyons of the Pechersk district of Kyiv by the main harmful substances contained in car exhaust gases was determined. For each of the street canyons, the critical intensity of traffic flows was determined, at which the level of pollution by the respective harmful substance reaches the maximum permissible value. The results of the study make it possible to quickly predict the level of air pollution in the roadside space of cities and, by controlling the parameters of the traffic flow, to prevent dangerous environmental situations and take the necessary environmental measures in a timely manner.

REFERENCES

1. Abramovsky E.R., Karpliuk V.I., Peremetchyk M.M. Atmosphere of large cities. 2nd edition, supplemented and corrected - Dnipro: Science and Education, 2011. 350 p.
2. Gutarevych Y.F., Zerkalov D.V., Govorun A.G., Korpach A.O., Merzhievska L.P. Ecology and road transport: Study guide. - K.: Aristey, 2006. - 292 p.
3. Lynnyk I.E., Lezhneva O.I., Dorozhko E.V. Ecological aspects of the motor transport complex: monograph - Kharkiv: Striped Printing House, 2020. - 194 p.
4. R. Berkowicz, M. Ketzel, S. S. Jensen, M. Hvidberg, O. Raaschou-Nielsen, Evaluation and application of OSPM for traffic pollution assessment for a large number of street locations. Environ. Model. Softw. 2008, 23, 296. doi:10.1016/J.ENVSOFT.2007.04.007.
5. Kakosimos, K.E.; Hertel, O.; Ketzel, M.; Berkowicz, R. Operational Street Pollution Mod-l (OSPM) - A review of performed application and validation studies, and future prospects. Environ. Chem. Vol. 7. P. 485-503 (2010.
6. Bakulich O.O., Oliynyk R.V., Samoilenko E.S. Potential environmental hazard of street canyons of the city. Bulletin of the National Transport University. - K.: NTU, 2015. - Issue (1) 31.
7. Polischuk V.P., Dziuba O.P. Traffic flow theory: methods and models of traffic organization: a textbook - K.: Znannya Ukrainy, 2008. - 175 p.
8. Bakulich O.O., Grebelnyk M.M., Samoilenko E.S. Management of environmental safety of the metropolis. Bulletin of the National Transport University. Series "Technical Sciences". Scientific and technical collection. 2022. Issue 1 (51). C. 12-20. DOI: 10.33744/2308-6645-2022-1-51-020-027.

9. Samoilenko E.S. Modeling the level of urban pollution by controlling the parameters of traffic flow. Bulletin of National Transport University. Series "Technical Sciences". 2022. Issue 3 (53). C. 322-328. DOI: 10.33744/2308-6645-2022-3-53-322-328.
10. Ilchenko V., Bondarenko V., Koroliova O., Petrovska S., Kumar R. An Analysis of Digital Technology Impact on Improving the Environmental Status. International Journal of Advanced Science and Technology. 2020. Vol. 29, no. 6s. P. 1087-1093. URL: http://sersc.org/journals/index.php/IJAST/article/view/9192. Scopus.