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The Risk to the Health of the Population Exposed to the Influence of the Road-Car Complex

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Abstract

Background: The growth of motorization of the population is accompanied by an increase in the number of environmental pollutants. In this study, the impact on public health risk indicators of not only gaseous but also dust components entering the environment during the operation of vehicles was studied.

Methods: A quantitative assessment of the impact of the process of operation of the road-car complex (DAC) of different intensity on air pollution. Then we determined the value of the indicator of risk to public health at different intensity of air pollution by products of operation of the DAC. The dependence of the risk to public health on the distance to roads with different traffic intensity was determined.

Results: The growth of motorization of the population has led to the formation of a high level of air pollution in megacities during the combustion of fuel, destruction of the road surface, parts of the braking system and tires of the car. Solid dust particles in atmospheric air samples are 70 % represented by aluminosilicates, which have a fibro genic effect, contain heavy metal compounds and substances with a pronounced carcinogenic effect (Benz-(a)-pyrene, di Benz- (a, h)-anthracene, Benz-(B)-fluoranthene and chrysene). It is shown that non-carcinogenic risk in the area of DAC influence with the intensity of traffic flows 2500-3000 cars / hour, in the period up to the age of 30 years is estimated as" negligible", in 40 years as" moderate", at the age of 50 years as" high", for the age over 53 years as" very high " Critical systems are respiratory and cardiovascular. The dependence of the risk value on the distance to the road is established.

Keywords: Risk Assessment; Road Transport; Air Pollution; Public Health; Life Expectancy

Introduction

Road transport has become the main source of air pollution in major cities. The negative impact on the health of the population of air pollutants of residential areas due to emissions of vehicles has not been fully studied, due to their multicomponent, as well as the extreme complexity of the organization of research in a metropolis. The only real possibility for obtaining quantitative characteristics of the potential threat is the use of methods for assessing and analyzing the risk to public health [1-17]. This study is aimed at assessing the level of air pollution (AB) and a comparative analysis of the risk to health of the population living in the zone of influence of chemical air pollutants at different distances from the DAC with different intensity of road transport.

Methods

Quantitative assessment of contamination of AV when operating the DAC of varying intensity. The following methods were used: chromatographic method for determination of organic compounds; atomic absorption method for determination of heavy metal compounds in the composition of solid dust particles; dust analyzer model 8520 for determination of PM10 and PM2.5 in the range of 0.001-100 mg / m^3. Air sampling was carried out continuously for 8-12 hours. The study was conducted in the period 2009-2013 (796 air samples, 3077 samples). Assessment of health risk conducted in accordance with the guidance "Guidance on risk assessment for public health when exposed to chemical pollutants environment" (P 2.1.10.1920-04) [3] for the population residing on territories in the zone of influence DAK with the intensity of traffic flow 2500 cars / hour. As a control of the territory adopted in the territory in the zone of influence DAK with intensity of movement of transport streams 1000 cars / hour. The indicators of carcinogenic and non-carcinogenic risk were determined. Additionally, for risk assessment used guidelines 2.1.10.0062 - 12 "quantifying noncancer risk from exposure to chemicals on the basis of evolutionary models" [4].

Study Design

On the basis of full-scale study determined the intensity of traffic flows in the selected study areas of the city. We took into account the composition of vehicles, the main categories of vehicles (trucks, buses, cars), engine type. Sections of highways in residential areas are grouped taking into account the intensity of traffic flows in the daytime: up to 500 cars per hour (7 sections); 1500-2000 cars per hour (8 sections); 2500 - 3000 cars per hour (7 sections). In the areas of influence of DAC with different intensity of traffic flows conducted full-scale studies of atmospheric air accredited laboratory. The identified characteristics of the level of air pollution allowed to form a database to identify the connection in the system "DAC-air pollution-risk to public health". At the final stage, we determined the value of the indicator of risk to public health at different intensity of air pollution by the products of operation of the DAC. The dependence of the risk to public health on the distance to roads with different traffic intensity was established.

Sensitivity Analysis

Metrological characteristics were evaluated during the certification of the methods used [5-7].

Results

The results of field studies conducted in residential areas of the city, in areas along the roads with different intensity of traffic flows (TP) allowed to establish the following. On the site with an intensity of 2500-3000 TP cars / hour revealed the most unfavorable situation. The maximum single concentration reached 3.3 maximum permissible concentration (MPC) for carbon monoxide, 8.2 MPC for nitrogen dioxide. In the area of TP 1500-2000 cars / hour they reached 3.1 MPC for carbon monoxide and 4.5 MPC for nitrogen dioxide per hour. In the TP area less than 500 cars / hour of carbon monoxide-2.9 MPC, nitrogen dioxide-2.2 MPC. Contamination of AB along the roads with fine dust particles occurs as a result of primary dust formation - combustion of fuel components and abrasive processes of DAC, as well as secondary dust formation (resuspending dust particles).

In the study of samples air of residential areas on the content of TSP at different distances from the roadway with traffic intensity of 2000-2500 watts./ hour at the edge of the road was determined 2.83 ± 0.51 mg / m^3; at a distance of 10 m-1.04 ± 0.12 mg/m^3; at a distance of 20 m-0.68 ± 0.15 mg/m^3; at a distance of 30 m -0.61 ± 0.10 mg/m^3; at a distance of 50 m - 0.48 ± 0.09 mg/m^3; at a distance of 60 m -0.42 ± 0.09 mg / m^3. The content of solid dust particles of different dispersion in samples AB at a distance of up to 10 m from the roadway is presented in Table 1. According to the chemical analysis of TSP samples in AB on 70 % are aluminosilicates and are in the state of microscopic particles. It was found that the average concentrations of Zinc, Iron, Cobalt, Lead, Chromium, Nickel, Exceed hygienic standards with traffic intensity of more than 1500 cars/hour (Table 2).

Table 1: Content of solid dust particles in atmospheric air samples in residential areas with traffic flows of different intensity (mg / m^3), M±m.

Dust particles	MPC, мг/м^3	Exceeding the maximum permissible concentration (MPC) at traffic intensity (cars/hour) M±m		
		≤500 (n = 112)	1500 - 2000 (n = 128)	2500- 3000 (n = 112)
TSP	0.5	0.61±0.13	2.1±0,54* t = 2.68	2.86±0,63* t = 3.50
PM10	0.3	0.39±0.09	1.49±0,36* t = 2.98	1.98±0,45* t = 3.46
PM2.5	0.16	0.15±0.04	0.51±0,11* t = 3.08	0.91±0,16* t = 4.61

Table 2: Content of metal compounds in atmospheric air samples along roads with different vehicle traffic intensity (mg / m^3).

Substance	MPC, мг/м^3	Exceeding the maximum permissible concentration (MPC) at traffic intensity (cars/hour) M±m		
		≤500 (n = 63)	1500–2000 (n = 96)	2500–3000 (n = 63)
Cu	0.002	0.16±0.04	0.75±0.02*	0.92±0.05*
Pb	0.0003	0.47±0.01	1.29±0.24*	1.84±0.27*
Cd	0.0003	<	<	0.02±0.003
Ni	0.001	0.01±0.002	1.02±0.14*	1.6±0.31*
Cr	0.0015	0.18±0.03	1.10±0.09*	1.14±0.095*
Co	0.0004	0.24±0.05	1.50±0.34*	1.83±0,39*
Zi	0.05	0.94±0.11	3.6±0.86*	4,65±0,94*
Fe	0.04	0.52±0.06	3.5±0.47*	4,26±0,52*

a) Differences are statistically significant P<0.05

b) Differences are statistically significant P<0.05

Differences between indicators of the content of all studied metals in samples of AB along the highway with intensity of TP to 500 cars/hour, 1500-2000 cars/hour and 2500-3000 cars/hour are statistically significant (p<0.05, f = 13 and f = 12, respectively).

Currently, there is an increase in environmental pollution by such super-toxic compounds as polycyclic aromatic hydrocarbons (PAHs). The main source of PAH in the area of the road network is emissions from road transport. Chromatographic study of atmospheric air samples in the residential area at the border of the highway with the intensity of TP 2500-3000 cars/hour identified 86 organic compounds, 34 of which are cumulative and have not been previously accounted for in the surface layer of the atmosphere clearly manifested dimethylnaphthalenes. Additionally, the following substances have been identified: Benz(a)anthracene, Benz(a)pyrene, Benz(e)pyrene, Benz (B) fluoranthene, Benz (k) fluoranthene, Benz (ghi) perylene, dibenz (a, h) anthracene, coronene, pyrene, chrysene. Of the identified substances, four (Benz (a) pyrene, dibenz (a, h) anthracene, Benz (b) fluoranthene and chrysene have a pronounced carcinogenic effect.

Discussion

It is established that the value of the indicators of carcinogenic risk in the zone of influence DAK with the intensity of the traffic flow 1000 cars/hour are mainly at the level of 10-4-10-5, typical for most major cities [9-11,18]. At the same time, the values of carcinogenic risk indicators in the zone with traffic intensity of 2500 cars/hour and above are at 10-2, which characterizes carcinogenic risk as "above acceptable". In international practice, this indicator corresponds to the quantitative criterion under which risk reduction measures should be implemented (Figure 1). The leading place among carcinogens is occupied by chromium and formaldehyde, followed by heavy metal compounds (Lead, Cobalt, Nickel and Cadmium). Heavy metal compounds and formaldehyde also contribute to the total non-carcinogenic risk index. Calculations have shown that the level of risk in the area with the intensity of TP 1000 cars/hour is estimated as "average". In the area with intensity TP 2500 cars/hour - as " extremely high."

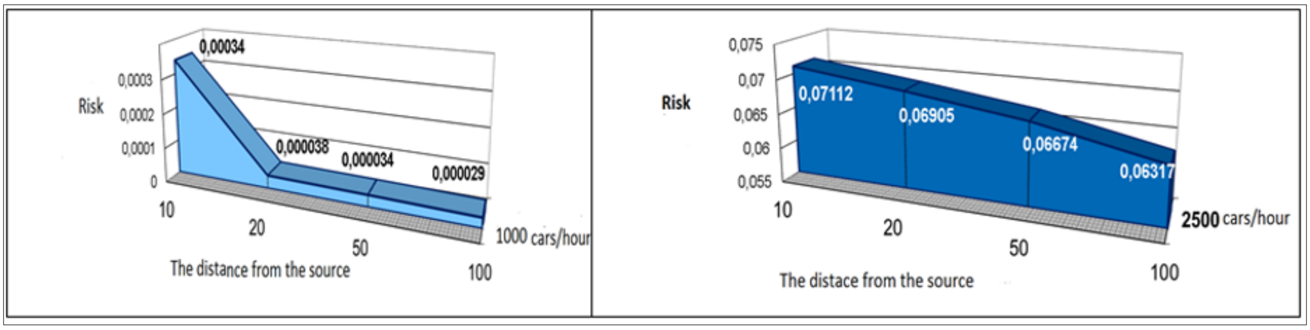

Figure 1: Carcinogenic risk in different parts of the residential area in the area of influence of the DAC with different intensity of traffic flows.

The main systems of non-carcinogenic risk are the respiratory and immune. In risk assessment using evolutionary models, it was found that the risk of health loss due to cardiovascular disease (CCC) due to chemical contamination of AB in areas with a TP intensity of less than 500 cars/hour is negligible and is less than 1.00 E-04 by age 73 [19,20]. The magnitude of the risk of health loss due to the pathology of the respiratory system throughout life in the area of DAC with an intensity of TP 2500-3000 cars/hour is 0.78 and almost 3 times higher than the risk of loss of health due to CCC pathology (0.26). The generalized risk before the age of 30 is negligible, at the age of 40 years as moderate, at the age of 50 years as high, for the age over 53 years as "very high". In addition, a reduction in life expectancy by 8.2 years (to 64.8 years, compared with the estimated life expectancy of 73 years) was revealed.

Conclusion

The results of the study of atmospheric air in the area of influence of the DAC allowed to establish that the process of operation of cars leads to environmental pollution TSP which includes heavy metal compounds and polycyclic aromatic hydrocarbons. The intensity of pollution depends on the intensity of traffic flow on the road network. The population living in the area affected by roads with heavy traffic has a risk of loss of health due to the pathology of the respiratory, cardiovascular systems, as well as carcinogenic pathology as a result of the influence of chemical air pollutants. The life expectancy of the population living under the influence in the area of DAK with the intensity of traffic 2500-3000 cars/hour, will be 64.8 years, i.e. 8.2 years less, compared with the exposure at a traffic intensity of less than 500 cars/hour.

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