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# Assessment of Risk from Atmospheric Air Pollution and Traffic Load Intensity in the City of Kazan (Republic of Tatarstan)

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**Abstract.** The growth of the vehicles' number in the cities, the proximity of mobile sources to residential areas, unsatisfactory road maintenance and emission toxicity exacerbate the problem of the atmospheric air quality in the cities. Assessment of exposure to solid particles, $PM_{10}$ and $PM_{2.5}$ in the four districts was carried out based of average annual concentrations performed by "The Center of Hygiene and Epidemiology in the Republic of Tatarstan" and the Municipal Institution "Automated traffic control system" (MUE ATCS) in the period of 2010 – 2017. High risk of developing non-carcinogenic effects for the population of the city of Kazan and the districts under study was associated with total exposure to suspended particulate matters, the contribution of which to the hazard index (HI) made 42.5% in the city of Kazan, 52.7% in the Vakhitovsky district, and 59.9% in the Sovetsky district. The results showed the necessity of shifting the time of the atmospheric air status control at the Air Pollution Observation Station (APOS) by 1 hour, which can result in compliance of the sampling time to maximum traffic flow. The assessment of epidemiological risk for the population health in the city microdistricts was carried out for the first time.

**Keywords: Atmospheric Air, Vehicles, Monitoring, Public Health Risk**

## 1 Introduction

The availability of urban area development prevents from rapid pollutants' dissipation in the air and thus aggravates the situation. The architectural and planning peculiarities of large cities affect the processes of pollutants' dissipation; predetermine the growth of the vehicle engine idle time resulting from the motor vehicle standing at the street junctions, contributing to higher emission of hazardous substances into the atmospheric air. The growth of the vehicles' number in the cities, the proximity of mobile sources to residential areas, unsatisfactory road maintenance and emission toxicity exacerbate the problem of the atmospheric air quality, in spite of the decrease of industrial emissions [1, 2]. Numerous epidemiological studies indicate adverse health effects from exposure to atmospheric air pollution [3, 4]. The issues of objective quality control and regulation of the state of the atmospheric air are becoming relevant.

This leaves it vital that risk-reduction procedures be pursued, and decision-support tools devised, on the basis of analyses and risk assessments.

## 2 Materials and Methods

Assessment of exposure to the pollutants coming with vehicles' emissions in four districts of the city of Kazan was carried out based on the results of retrospective studies of average annual concentrations at the Air Pollution Observation Stations (APOS) for the period of 2010 – 2017. Sampling is carried out during 20 minutes 4 times a day at intervals of 6 hours: 1.00 a.m., 7.00 a.m., 13.00 p.m., and 19.00 p.m. with subsequent analysis. The assessment of epidemiological risk for the population health in the city microdistricts was carried out for the first time. The assigned areas corresponded geographically to the location of APOS: APOS -3 in the Vakhitovsky district; APOS-8 in the Sovetsky district; APOS-11in the Novo-Savinovsky district and APOS-15in the Gorki. Information on the traffic intensity in the city of Kazan was additionally completed with the data from the MUE ATCS, the major activity of which is the road-traffic safety with computer use [5]. The calculation of the traffic intensity was performed during air sampling at the APOS. The risk assessment of the development of non-carcinogenic effects from pollutants contained in the air was carried out according to the total hazard index (HI) in accordance with Guidelines R 2.1.10.1920-04[6].

## 3 Results (Times New Roman 12)

The analysis of laboratory studies of the atmospheric air in the city of Kazan showed that 7–13 pollutants were controlled in APOS. Most of them (nitrogen dioxide, sulphur dioxide, carbon oxide, suspended particulates, and formaldehyde) are on the list of priority substances contained in the atmospheric air of the cities of the Russian Federation and the inventory list of toxic substances' emission of the U.S. EPA. For the period under study, the contribution of the automobile transport to atmospheric pollution in Kazan remained high and contributed 69.4%–73.8% of the total gross emissions. Average annual concentrations of suspended particulate matters PM10 exceeded an MAC in the APOS -3, APOS-11 and APOS-15 by a factor of 2.0 – 2.45, and in PM2.5 – by a factor of 1.54 and 2.1, correspondingly. APOS-8 was identified as a control one in the content of PM10 and PM2.5 fractions, the level of which was within the limits of regulations.

We assessed the health risk for the population of the city of Kazan in the specified districts due to the atmospheric air pollution. The value of the total hazard index (HI) of the chemicals coming with exhaust gases from vehicles in the districts under study made 13.7; 14.51; 14.09; 11.8, and that corresponded to a high risk. High risk of developing non-carcinogenic effects for the population of the districts under study was associated with total exposure TSP, the contribution of which to HI made 42.5% in the Sovetsky, 52.7% in the Vakhitovsky, 56.9% in the Gorki and 58,9% in the Novo-Savinovsky districts.

The calculation of the traffic intensity was performed during air sampling at the APOS. At APOS-3, the periods with maximum traffic were registered in the morning from 8.20 a.m. - 8.40 a.m. (8% of all maximums within a year), and in the evening from 6.00-6.20 p.m. (10 %) and from 5.00 p.m. – 5.20 p.m. (14%). The air sampling time agrees with neither maximum of the traffic flow, and this fact results in discrepancy in the morning – 52% of the total maximum traffic, and in the evening – 24%. At APOS- 8, the traffic intensity increases after 7.00 a.m., and the difference between 7.00 a.m. -7.20 a.m. and 7.20 a.m. – 7.40 a.m. makes 23%, and between the last one and 8.40 a.m. - 9.00 a.m. – 37%. At APOS-11 and APOS-15 the periods with maximum traffic were registered in the morning from 7.00 a.m. - 9.00 a.m., and in the evening from 4.40-6.00 p.m. (Table 1).

**Table 1.** Maximums of vehicle passage at time of day intervals (the number of vehicles)

| Time interval | APOS -3 | APOS -8 | APOS -11 | APOS -15 |
|---|---|---|---|---|
| 1.00-1.20 | 577 | 1094 | 1132 | 1134 |
| 2.00-2.20 | 409 | 739 | 747 | 850 |
| 7.00-9.00 | 1934-2948 | 5556 - 7616 | 10260-11966 | 10298-11966 |
| 13.00-13.20 | 2838 | 7729 | 8859 | 8293 |
| 14.00-14.20 | 2867 | 7760 | 8979 | 8107 |
| 16.40-18.00 | 2550-2749 | 7800-8526 | 9243 -12321 | 9062-10006 |
| 18.00-18.20 | 2931 | 9024 | 12101 | 9873 |
| 18.20-20.20 | 2474-2093 | 8101-6029 | 11736-7390 | 9616-7202 |

According to the level of the traffic mitigation the districts under study are arranged as follows, The crossroads at the APOS -11, APOS -15, APOS - 8 and APOS - 3. Correlation analysis was carried out according to Spearman criterion ($p<0.05$). The correlation dependencies between the traffic intensity and the pollutants' concentration (the suspended solids $r = 0.15\text{-}0.30$, carbon oxide $r = 0.17\text{-}0.23$, nitrogen dioxide $r = 0.18\text{-}0.51$, phenol $r = 0.16\text{-}0.25$) were revealed.

## 4 Discussion (Times New Roman 12)

Epidemiological and toxicological data show that a mass of PM (PM2.5, PM10) contains fractions of varying types and degrees of the health impact. Our results corroborate the existing evidence of the fact that atmospheric air pollution is a significant environmental risk factor for the population health [2, 7]. High risks of developing non-carcinogenic effects for the population of the city of Kazan and the districts under study were associated with total exposure to suspended particulate matters. Meanwhile, in scientific literature, clear emphasis is placed on the opinion that quantitative methods of analysis and risk assessment form the basis of safety management, as part of a critical infrastructure [8]. This is especially of concern in urban areas, where large numbers of people live in the immediate vicinity of substantial road traffic emissions.

# 5 Conclusions (Times New Roman 12)

Currently, the existing monitoring system in the area of the main traffic arteries in the city of Kazan makes it impossible to correctly assess the vehicles' impact on the atmospheric air quality. The key result of our study is taking into account of supplementary data on the traffic flow intensity in districts of the city, which enabled us to differentiate the long-term effects of the atmospheric air pollution with vehicles on the population health. The results of analysis showed the necessity of shifting the time of the atmospheric air status control at the APOS by 1 hour, which can result in compliance of the sampling time to maximum traffic flow. The use of ATCS data will allow decreasing the traffic-light creep up to 30% in peak periods and reducing the air environment pollution with exhaust gases. The necessity of determining the risk reduction efficiency with the account of economic factors will provide the basis for future studies. The risk reduction can influence on the level of the project of modernization of the system for the atmospheric air pollution control and preventive measures. The most effective decisions as regards the risk reduction should be implemented

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