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IMPACT OF ROAD TRANSPORT ON THE LEVEL OF AIR POLLUTION IN THE CITY OF ALMATY

The article deals with the analysis of the impact of vehicles on the pollution of the air basin of the city of Almaty with emissions of toxic substances. By analyzing and processing information from various sources, the causes and serious consequences of air pollution by vehicles were shown. Recently, as is known, more than 90% of all carcinogenic substances polluting the air environment of the city of Almaty account for the annual increase in road transport. The results of our study on the degree of intensity of traffic of cars and trucks showed that the largest number of motor vehicles in Almaty falls on Raiymbek (30.4%), Ryskulov (28.1%), Sain (24.3%) and Al- Farabi (12.8%), the smallest number of cars is observed on Seifullin (5.7%) and Nazarbayev (5.5%) avenues. The largest number of trucks falls on Ryskulov (28.1%), Raiymbek (24.1%), Sain (22.4%) and Al-Farabi (12.7%) avenues, and the smallest number of them is the same as cars, i.e. Seifullin Avenue (7.2%) and Nazarbayev Avenue (5.2%). In order to improve the air environment of the city of Almaty, it is necessary to take measures that will contribute to the greening of vehicles, reduce negative trends in air pollution from stationary sources in the city, increase the connection of private houses to gas and expand the areas of green spaces in the metropolis.

Key words: Almaty, metropolis, vehicles, air basin, toxic substances.

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Автокөліктің Алматы қаласының атмосфералық ауасының ластану деңгейіне әсері

Мақалада Алматы қаласының ауа бассейнінің улы заттар шығарындыларымен ластануына автокөліктердің әсерін талдау қарастырылған. Әр түрлі көздерден алынған ақпаратты талдау және өңдеу арқылы атмосфераның автокөлік құралдарымен ластануының себептері мен ауыр салдары көрсетілді. Қазіргі уақытта Алматы қаласының әуе ортасын ластайтын барлық канцерогенді заттардың 90% – дан астамы автокөліктердің жыл сайынғы ұлғаюына тиесілі екені белгілі. Жеңіл және жүк автокөліктерінің қозғалыс қарқындылығының дәрежесі бойынша біздің зерттеуіміздің нәтижелері Алматыда жеңіл автокөліктердің ең көп саны Райымбек (30,4%), Рысқұлов (28,1%), Саин (24,3%) және Әл-Фараби (12,8%) даңғылдарына тиесілі екенін көрсетті, жеңіл автокөліктердің ең аз саны Сейфуллин (5,7%) және Назарбаев (5,5%) даңғылдарында байқалды. Жүк көліктерінің ең көп саны Рысқұлов (28,1%), Райымбек (24,1%), Саин (22,4%) және Әл-Фараби (12,7%) даңғылдарына тиесілі және олардың ең аз саны жеңіл автокөліктермен бірдей, яғни Сейфуллин даңғылы (7,2%) және Назарбаев даңғылы (5,2%). Алматы қаласының ауа ортасын жақсарту үшін көлік құралдарын экологияландыруға, қаладағы стационарлық көздерден ауа ортасын ластау бойынша жағымсыз үрдістерді төмендетуге, жеке үйлерді газға қосуды ұлғайтуға және мегаполистің жасыл желектер алаңдарын кеңейтуге ықпал ететін іс-шараларды жүзеге асыру қажет.

Түйін сөздер: Алматы, мегаполис, көлік құралдары, әуе бассейні, улы заттар.

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Влияние автотранспорта на уровень загрязнения атмосферного воздуха города Алматы

В статье рассматривается анализ влияния транспортных средств на загрязнение воздушного бассейна города Алматы выбросами токсичных веществ. Путем анализа и обработки информации из разных источников были показаны причины и серьезные последствия загрязнения атмосферы транспортными средствами. В настоящее время, как известно, более 90% всех канцерогенных веществ загрязняющих воздушную среду города Алматы приходится на ежегодное увеличение автомобильного транспорта. Результаты нашего исследования по степени интенсивности движения легковых и грузовых автомобилей показали, что наибольшее количество автомобильного легкового транспорта в Алматы приходится на проспекты Райымбека (30,4%), Рыскулова (28,1%), Саина (24,3%) и Аль-Фараби (12,8%), наименьшее количество легковых автомобилей наблюдается на проспектах Сейфуллина (5,7%) и Назарбаева (5,5%). Наибольшее количество грузовых автомобилей приходится на проспекты Рыскулова (28,1%), Райымбека (24,1%), Саина (22,4%) и Аль-Фараби (12,7%), и, наименьшее количество их одинаково с легковыми автомобилями, т.е. проспект Сейфулина (7,2%) и проспект Назарбаева (5,2%). Для оздоровления воздушной среды города Алматы необходимо осуществления мероприятий, которые будут способствовать экологизации транспортных средств, снижению негативных тенденций по загрязнению воздушной среды от стационарных источников в городе, к увеличению подключения к газу частных домов и расширению площадей зеленых насаждений мегаполиса.

Ключевые слова: Алматы, мегаполис, транспортные средства, воздушный бассейн, токсические вещества.

Introduction

Currently, atmospheric air pollution is one of the urgent problems of large and industrial cities of the republic. Among them, the leading place in terms of the concentration of harmful substances is occupied by the city of Almaty. One of the serious negative consequences is the formation of toxic substances in the air in mountainous areas due to natural conditions, climatic, man-made conditions, location at the foot of the Trans-Ili mountains, characteristic weak circulation of air masses in the area, which is extremely unfavorable for ensuring cleanliness (figure 1). Over the past 20 years, Almaty has been ranked among the 25 most polluted cities in the world. The main reason why Almaty has become the most polluted city in Kazakhstan is cars, where vehicles account for about 90% of the total volume of toxic substances released into the air from all modes of transport. In Almaty, the number of cars today exceeds 823 thousand, in addition, 90 thousand non-resident cars enter the city every day and the number of trucks is growing. The air pollution index in recent years was equal to 12-14 units. However, the share of pollution from stationary sources is only 4.1%, the rest is accounted for by vehicles. In recent years, the state of the air basin of the city of Almaty has deteriorated sharply due to the growth of the urban population and the reduction in the areas of green areas and the large volume of construction of high-rise buildings that hold back air flows, sources of pollution, especially cars [1,2].

The foregoing determined the purpose of our study, including the determination of the impact of vehicles in air pollution by emissions of harmful substances in the city of Almaty.

Materials and research methods

To study air pollution in the city of Almaty, the method for calculating the emissions of harmful pollutants by vehicles into the atmospheric air was used, based on the international methodology for inventorying emissions of pollutants EMEP / CORINAIR [3]. The method allows to determine emissions of greenhouse gases into the atmosphere from motor vehicles. To calculate the indicators, traffic intensity data was collected. The data was collected as a result of the study. The object of our study were roads for motor transport in Almaty. The subject of this scientific study was road congestion, traffic intensity. The research was carried out in Almaty in June, July 2021. 6 main observation points were chosen: 11. – Ryskulov avenue, 2. – Seifullin avenue, 3. – Raiymbek avenue, 4. – Al-

Farabi avenue, 5. – Nazarbaev avenue, 6. – Sain avenue. The research method was to monitor the number of passing cars. During the study, cars were divided into 2 categories: cars and trucks. The tests were carried out for 8 weeks, four times a day. The observation time is 20 minutes. As a result, all the received data were entered into a single data array in the Excel program.

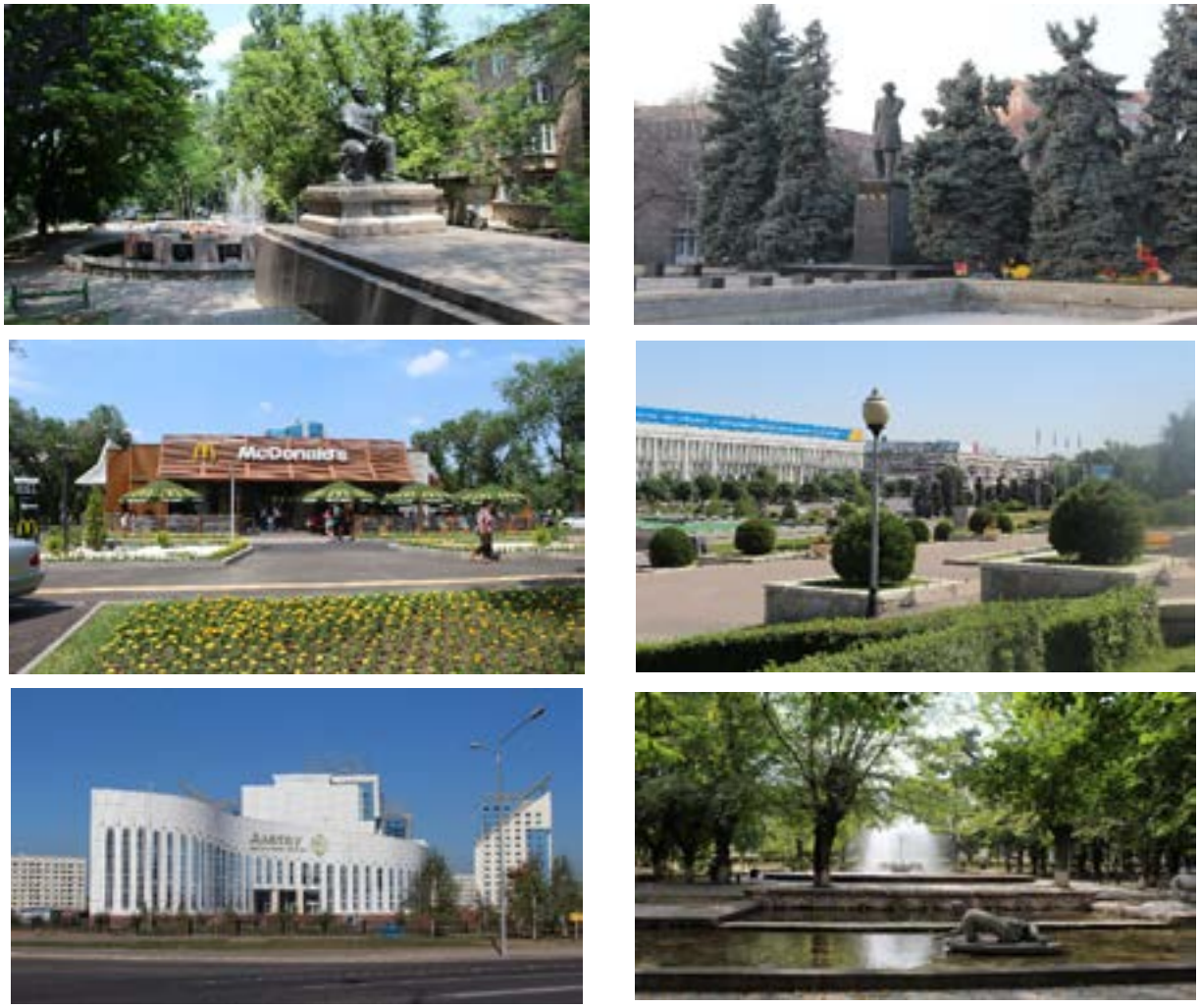


Figure 1 – Almaty city

Results and their discussion

Today, one of the main sources of pollutants entering the air basin of our planet is road transport. 83% of passenger cars of the entire globe, which account for 78%, then emissions from stationary sources of industrial enterprises account for 11% and about 6% of the total emissions of pollutants into the air come from thermal power facilities. So, for example, the share of road transport in the United States in environmental pollution accounts for more than 60%, in the UK this percentage reaches 34%, for France it is 32%. At the same time, the number of vehicles on our planet is only growing every year. The issue of air pollution by vehicles was considered by many researchers [4,5,6,7,8,9]. The main load on roads is due to the annual growth in the number of all modes of transport, which leads to an increase in traffic intensity on the roads, which in turn affects and affects the quality of the urban air environment. Harmful and toxic substances in exhaust gases emitted by vehicles contain not only carbon monoxide, unburned hydrocarbons, nitrogen oxides and soot, but also aldehydes, sulfur oxides and other carcinogenic compounds. All these compounds are not only toxic, but also reduce the

transparency of the atmosphere: 50% more fog, 10% more precipitation, reduce solar radiation by 30%. The thermal effect increases the temperature in the city by 3-5°C, the frost-free period by 10-12 days and the snow-free period by 5-10 days [3, 9]. Currently, there are many state standards for calculating motor vehicle air pollution. According to the above method, we calculated the emissions of motor vehicles into the air of the city of Almaty. Traffic data was collected to calculate the indicators. An experimental study was conducted by us in the summer, in June and July 2021 in Almaty. 6 main control points were chosen: 1. – Ryskulov avenue, 2. – Seifullin avenue, 3. – Rayymbek avenue, 4. – Al-Farabi avenue, 5. – Nazarbaev avenue, 6. – Sain avenue. The research method was to monitor the number of passing cars. During the study, cars were divided into 2 categories: cars and trucks. The tests were carried out for a week, four times a day. The observation time is 20 minutes. The next step in preparing data for calculating emissions was the distribution of pollutants according to the required classification.

The 2021 traffic volume data for Almaty for 2021 (total number of vehicles) obtained using the statistics on the composition of vehicles was divided into the following types:

- cars;
- trucks and buses with gross weight up to 3500 kg;
- trucks with gross weight over 3500 kg.

During the study period, on six streets (Ryskulov, Seifullin, Raiymbek, Al-Farabi, Sain and Nazarbaev (former Furmanova) of Almaty city, for 20 minutes, 4 times a day, we collected complete information on the traffic intensity of each calculated type of transport (Figure 1) The studied section of the road is 500 meters. After analyzing the dataset obtained using statistical indicators, the main conclusions were drawn regarding the dynamics of traffic intensity on urban roads. The results of the calculations for this period are presented in figure 2.

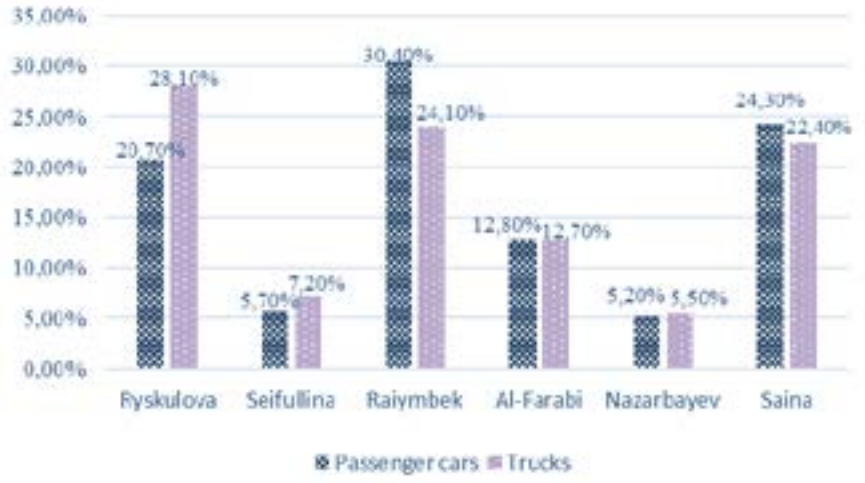


Figure 2 – The degree of traffic intensity during the study period on the researched streets of Almaty

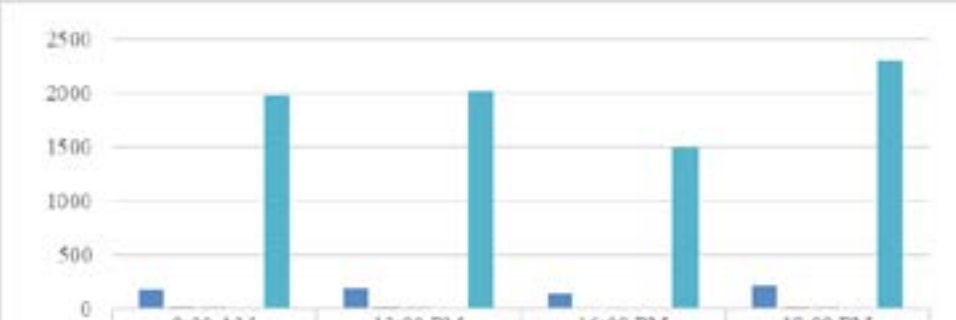
According to the results of the study on the degree of traffic intensity, the largest number of motor vehicles in Almaty falls on cars along Raiymbek (30.4%), Ryskulov (28.1%), Sain (24.3%) and Al-Farabi avenues (12,8%), the smallest number of cars falls on Seifullin avenues (5.7%) and Nazarbayev avenues (5.5%). If we look at trucks, the largest number of them falls on Ryskulov (28.1%), Raiymbek (24.1%), Sain (22.4%) and Al-Farabi (12.7%) avenues, the smallest number to Seifullin Avenue (7.2%) and to Nazarbayev Avenue (5.2%) (Figure 1). The largest number of cars, namely 77102 units, was observed along Raiymbek avenue. The smallest number of cars was observed along Nazarbayev Avenue – 13372 units. The next item of the study is the calculation of the main emissions of toxic substances into the air by vehicles according to the formula «calculation of emissions of harmful pollutants into the atmospheric air of the Republic of Kazakhstan».

$$M_{ipj} = g_{ipj} \cdot Q_{pj} \cdot 10^{-3}$$

gipj is the emission standard of the I-th pollutant of the j-th calculated type of vehicle when using the P-type of fuel, g / kg.

Qpj-consumption of motor fuel of the P-th type by vehicles of the j-th settlement type for a certain period, tons [1];

As noted above, according to the study, the largest amount of road transport in Almaty falls on Raiymbek avenue. Using the methodology that was given by us earlier, we calculate the main emissions of pollutants for Raiymbek avenue. I would like to emphasize that using this method, we obtain indicators of pollutants that are directly proportional to the number of vehicles (traffic intensity).



	9:00 AM	13:00 PM	16:00 PM	18:00 PM
CO	185	189,1	140,1	216,5
VOC	22,94	23,45	17,38	26,85
NOX	22,2	22,7	16,82	25,98
SO2	0,399	0,408	0,3028	0,4677
CO2	1975,8	2020,5	1497,2	2312,8

Figure 3 – Euro (0)-P emissions of motor vehicles

As can be seen from Figure 3, we recorded 6,080 cars on Raiymbek Street for 20 minutes on 21.07.21 at 18:00 in the evening, of which 185 vehicles were trucks. Accordingly, they had the following indicators:

Euro (0) – P
$M(CO) = 3465 \div 1000 \cdot 0{,}25 \cdot 250 \cdot 10^{-3} = 216{,}5 \cdot 10^{-3}$
$M(VOC) = 3465 \div 1000 \cdot 0{,}25 \cdot 31 \cdot 10^{-3} = 26{,}85 \cdot 10^{-3}$
$M(NO_X) = 3465 \div 1000 \cdot 0{,}25 \cdot 30 \cdot 10^{-3} = 25{,}98 \cdot 10^{-3}$
$M(SO_2) = 3465 \div 1000 \cdot 0{,}25 \cdot 0{,}54 \cdot 10^{-3} = 0{,}4677 \cdot 10^{-3}$
$M(CO_2) = 3465 \div 1000 \cdot 0{,}25 \cdot 2670 \cdot 10^{-3} = 2312{,}8 \cdot 10^{-3}$

Euro (1) – P
$M(CO) = 2615 \div 1000 \cdot 0{,}35 \cdot 21{,}5 \cdot 10^{-3} = 19{,}67 \cdot 10^{-3}$
$M(VOC) = 2615 \div 1000 \cdot 0{,}35 \cdot 2{,}4 \cdot 10^{-3} = 2{,}196 \cdot 10^{-3}$
$M(NO_X) = 2615 \div 1000 \cdot 0{,}35 \cdot 5{,}8 \cdot 10^{-3} = 5{,}308 \cdot 10^{-3}$
$M(SO_2) = 2615 \div 1000 \cdot 0{,}35 \cdot 0{,}54 \cdot 10^{-3} = 0{,}494 \cdot 10^{-3}$
$M(CO_2) = 2615 \div 1000 \cdot 0{,}35 \cdot 3120 \cdot 10^{-3} = 2855{,}5 \cdot 10^{-3}$

Euro (0) – D 3500 kg (light)
$M(CO) = 140 \div 1000 \cdot 0{,}14 \cdot 30 \cdot 10^{-3} = 0{,}588 \cdot 10^{-3}$
$M(VOC) = 140 \div 1000 \cdot 0{,}14 \cdot 10 \cdot 10^{-3} = 0{,}196 \cdot 10^{-3}$
$M(NO_X) = 140 \div 1000 \cdot 0{,}14 \cdot 50 \cdot 10^{-3} = 0{,}98 \cdot 10^{-3}$
$M(PM) = 140 \div 1000 \cdot 0{,}14 \cdot 4 \cdot 10^{-3} = 0{,}0784 \cdot 10^{-3}$
$M(SO_2) = 140 \div 1000 \cdot 0{,}14 \cdot 1{,}6 \cdot 10^{-3} = 0{,}0313 \cdot 10^{-3}$
$M(CO_2) = 140 \div 1000 \cdot 0{,}14 \cdot 3020 \cdot 10^{-3} = 59{,}19 \cdot 10^{-3}$

Euro (1) – D 3500 kg (heavy)
$M(CO) = 123 \div 1000 \cdot 0{,}10 \cdot 8{,}6 \cdot 10^{-3} = 0{,}105 \cdot 10^{-3}$
$M(VOC) = 123 \div 1000 \cdot 0{,}10 \cdot 4{,}3 \cdot 10^{-3} = 0{,}0528 \cdot 10^{-3}$
$M(NO_X) = 123 \div 1000 \cdot 0{,}10 \cdot 25 \cdot 10^{-3} = 0{,}307 \cdot 10^{-3}$
$M(PM) = 123 \div 1000 \cdot 0{,}10 \cdot 1{,}4 \cdot 10^{-3} = 0{,}0172 \cdot 10^{-3}$
$M(SO_2) = 123 \div 1000 \cdot 0{,}10 \cdot 1{,}6 \cdot 10^{-3} = 0{,}0196 \cdot 10^{-3}$
$M(CO_2) = 123 \div 1000 \cdot 0{,}10 \cdot 3090 \cdot 10^{-3} = 38{,}007 \cdot 10^{-3}$

Thus, for Raiymbek Avenue, we calculated the indicators of the main emissions of pollutants from cars of the ecological class Euro 0 and Euro 1 on gasoline fuel and the indicators of the main emissions of pollutants from trucks of the ecological class Euro 0 and Euro 1 on diesel fuel. The calculation results showed that among all the polluting components that were emitted into the atmosphere, the largest amount is carbon monoxide CO_2 (91%). The pollutant component CO_2 from passenger cars of the Euro (1)-B emission class was emitted into the atmosphere in a smaller amount than emissions from Euro (0)-B vehicles. Among the pollutants from Euro (1)-DL trucks, carbon monoxide CO_2 emissions are the highest (94%) compared to Euro (0)-DL trucks. In the air basin of the city of Almaty, emissions of polluting components CO, VOC, NOX,

SO_2, and PM are in a smaller amount compared to carbon monoxide.

As noted above, the most important environmental problem of the city of Almaty is air pollution. Specific natural and climatic features, the low level of natural blowing of the study area affect the degree of growth of toxic substances in the surface layer of the atmosphere, which leads to the formation of smog (Figure 4).

The determining pollutants of the air basin for the city of Almaty are carbon monoxide, nitrogen dioxide, sulfur dioxide and impurities, which to a large extent have a negative impact on the health of the urban population (Figure 5).

Figure 4 – Smog over Almaty

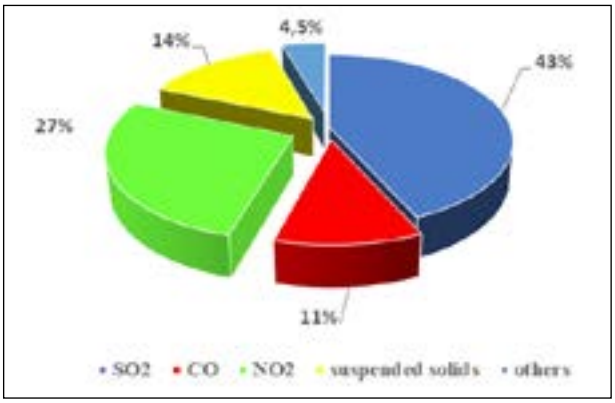


Figure 5 – The main pollutants of the atmospheric air of Almaty (2021)

The high level of pollution is due to both natural and climatic features of the area, and anthropogenic impact on the environment. The air quality is assessed by comparing the measured concentrations with the maximum allowable concentrations. The table below shows information on the content of harmful substances in the air basin of Almaty for the last 2017-2020 according to the statistics of the hydrometeorological service (table 1).

Table 1 – Maximum permissible concentrations (MPC) of atmospheric pollution by pollutants in 2017-2021 in the city of Almaty

Atmospheric pollutants	2017		2018		2019		2020		2021	
	MPC a.d	MPC m.s	MPC a.d	MPC m.s	MPC a.d	MPC m.s	MPC a.d	MPC m.s	MPC a.d	MPC m.s
Suspended particles (dust)	1,1	3,5	1,1	5.2	1.1	1.8	1,0	1,9	1,1	2,5
Sulfur dioxide	1,1	3,5	2,5	4.0	2.6	4.0	1,6	4,8	0,7	3,8
Nitrogen dioxide	1,8	2,5	1.5	9,1	1.6	9,5	1,7	4,8	2,1	3,1
Formaldehyde	1,2	1,2	1.2	1.0	1.4	1,0	1,3	0,7	1,2	0,9
Carbon monoxide		4,1		2.5		3.2	0,2	5,1	0,4	2,1
Phenol		1,4		1.0		1.0	0,4	1,3	0,4	0,8

As can be seen from the above data for the specified period for the city of Almaty, the most severe air pollution occurs in 2019. The average concentration of pollutants: suspended solids (dust) – 1.1, MPC, sulfur dioxide – 2.6, MPC nitrogen dioxide – 1.6, MPC formaldehyde – 1.4. The concentration of heavy metals and other pollutants did not exceed MPCa.d.,, the maximum one-time concentration of nitrogen dioxide pollutants was 9.5. MPCm.s. of fine suspended particles PM-2.5 – 6.3, MPCm.s. of sulfur dioxide – 4.0, MPCm.s. of small suspended particles RM-10 – 3.5, MPCm.s. of carbon monoxide – 3.2, MPCm.s. of nitric oxide – 1,8, MPCm.s. of suspended substances (dust) –

1,8, MPCm.s. of phenol – 1,0. The concentration of other pollutants did not exceed MPCm.s.. The concentration of other harmful substances did not exceed the maximum permissible norm.

The figure below shows the dynamics of the state of changes over ten years of air pollution in the city of Almaty according to Kazhydromet data (Figure 6).

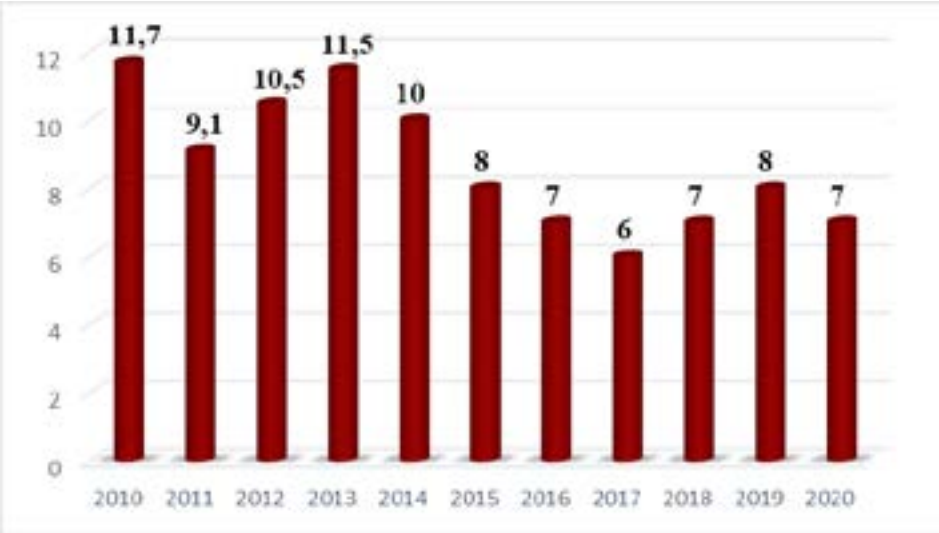


Figure 6 – Atmospheric pollution index (API_5) for Almaty for 2010-2020

It is known that the city of Almaty, in comparison with other cities of the republic, is characterized by a high level of air pollution. If we consider the level of atmospheric pollution by the value of the complex index calculated for the five substances indicated in Table 5, then this index has somewhat settled in recent years, but it still remains high. From the table, you can see the decline in the index from 8.0 to 7.0 in the period from 2015 to 2020 [10, 11].

Conclusion

Thus, as our studies have shown, observing the number of passing cars in 20 minutes in the city of Almaty, the share of road transport in the total number of emissions was more than 35%, which indicates that vehicles are the main air pollutant. The result of the calculations showed that the intensive load on the urban transport network is carried out on weekdays, during the daytime. The highest concentration of vehicles is observed on Raiymbek, Ryskulov, Sain, Al-Farabi avenues. It should be noted that the air basin of the city of Almaty is determined by a high level of pollution. The air pollution index (API) was 7.0. It has been established that the territory of the city of Almaty is heterogeneous in terms of the level of air pollution. So, against the background of a decrease in the complex indicator of atmospheric air pollution IZA5 on average for the city, in certain districts of the city where observation posts of the Kazhydromet system are installed, on the contrary, its growth is observed. It should also be noted that the dynamics of changes in the level of atmospheric pollution over the past 10 years has not been stable. It is possible to single out a period of API decrease (from 2015 to 2021) and rise (2010-2014). The main components of air pollution in Almaty are dust, sulfur dioxide, carbon monoxide, nitrogen dioxide, phenol and formaldehyde, the average concentrations of these chemical elements are several times higher than the maximum allowable concentrations. To improve the environmental situation of the city of Almaty, it is necessary to act in three main areas, including: the greening of vehicles, the reduction of air pollution from stationary sources, including the gasification of the private sector, the preservation and development of the green fund.

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