Air pollution problems of a Russian Federation region and ways of their solution

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Abstract. The paper deals with the problem of air pollution in one of the biggest regions of the Russian Federation which is Krasnoyarsk Territory. It is noted that the atmospheric air in the cities of the region is very polluted. The paper proposes measures to be taken to maintain an appropriate state of the environment.

For many thousands of years, man lived in harmony with his natural environment. But then the twenty-first century came. This historical stage is a time of scientific and technological progress. With the onset of the industrial revolution, the negative influence of man on the environment began to increase exponentially. This industrial progress has caused very serious problems.

Today, in almost all corners of the planet, with rare exceptions, it is possible to find cities with a large number of cars, factories and plants. All these negative processes are caused by tons of polluting harmful substances that are emitted into atmospheric air by industrial enterprises. The situation is complicated by the fact that in large cities there are almost no greenery and trees, which, as we know, are the lungs of the planet.

In various studies (N N Klyuev, L M Yakovenko) it is indicated that Russia, according to a fairly wide range of parameters, is a country that is quite prosperous from an environmental point of view. However, it should be noted that environmental problems are usually local. Often they are associated with a high level of urban air pollution. Such cities, as it is noted by such researchers as E A Chaykina, R G Khlebopros, A A Blueberry and others include most of the cities of the Krasnoyarsk Territory [1].

Environmental pollution is one of the most urgent and important problems in modern society. The life of our planet depends on how carefully we treat natural resources and air. In our country, environmental problems of the Krasnoyarsk Territory occupy a leading position. If we take into account the total mass of pollutant emissions from stationary sources, the Krasnoyarsk Territory ranks first among all the subjects of the Russian Federation. Since 2000 there has been a steady increase in air pollution in this area [2].

The largest industrial enterprises of the Krasnoyarsk Territory (Norilsk Mining Company, Krasnoyarsk Aluminum Plant, Nazarovskaya SDPP, Achinsk Alumina Plant, Krasnoyarsk CHP-1, Krasnoyarsk SDPP-2) emit almost 90 % of the emissions of all stationary sources into the atmospheric air, which constitutes up to 2,210 thousand tons. Cities that are industrial centres of the Krasnoyarsk Territory, such as Achinsk, Krasnoyarsk, Minusinsk, Lesosibirsk and Norilsk, are in the list of the cities that have the highest level of air pollution [3].
The level of air pollution in the cities of the Krasnoyarsk Territory according to the materials of the Federal State Budgetary Institution “Central Siberian UGMS” [4] is presented in Table 1.

**Table 1. The level of air pollution in cities of the Krasnoyarsk Territory.**

| City       | 2016      | 2017      |
|------------|-----------|-----------|
| Achinsk    | High      | High      |
| Kansk      | Low       | Rather high |
| Krasnoyarsk | Very high | Very high |
| Lesosibirsk | Very high | Very high |
| Minusinsk  | Very high | Very high |
| Nazarovo   | High      | High      |
| Norilsk    | Very high | Rather high |

The level of air pollution in the capital of the region in 2017 was characterized as “very high”. The complex index of atmospheric pollution was IZA5 > 14, the standard index (SI) for benzo (a) pyrene was 20.1, the highest frequency (HF) of the formaldehyde exceeding MPCmr - 23.1%.

During the year, 20 cases of “high” pollution with benzo (a) pyrene were recorded. In December 2017, the average monthly concentrations of benzo (a) pyrene exceeded the hygienic standard at all posts of the Central Siberian UGMS in Krasnoyarsk by more than 10 times. Also cases of exceeding 10 PDS.s. were detected in January and February. Compared to 2016, the citywide level of air pollution has not changed [4].

Such indicators of the atmospheric air were affected by the following pollutants: formaldehyde, benzo (a) pyrene, nitrogen dioxide, suspended solids and ammonia [5].

In 2018 the level of air pollution in the city of Krasnoyarsk was characterized as “high” (IZA5 ≥ 7), the standard index (SI) was 14.78 (for hydrogen sulfide), the highest frequency (HF) of the maximum permissible concentration was 14.12% (for formaldehyde). From July to September 2018, in the atmosphere of the regional capital, cases of exceeding the hygienic standards for suspended substances, carbon oxide, nitrogen dioxide, phenol, hydrochloride, formaldehyde and cumene were recorded. The highest repeatability of MPC exceedances was observed in the Leninsky district.

In 2018 the level of air pollution in Berezovka village was characterized as “rather high” (IZA5 ≥ 2), the standard index (SI) was 3.45 (for suspended substances (up to 2.5 μm)), the highest frequency (HF) of the maximum permissible concentration was 1.01% (by weighted substances (up to 2.5 microns)).

In 2018 the level of air pollution in the city of Achinsk was characterized as “rather high” (IZA5 ≥ 2), the standard index (SI) was 3.9 (for hydrogen sulfide), the highest frequency (HF) of the maximum permissible concentration was 0.3% (by weighted substances (up to 2.5 microns)).

In 2018 the level of air pollution in the city of Zelenogorsk was characterized as “rather high” (IZA5 ≥ 2), the standard index (SI) was 10.5 (for hydrogen sulfide), the highest frequency (HF) of the maximum permissible concentration was 2.6% (for dioxide nitrogen).

Certainly, the impact of chemical pollution of atmospheric air has had an impact on the growth of the incidence rate of the regional population in terms of the class of diseases of the circulatory organs, nervous system, malignant neoplasms and respiratory organs. Due to the imposition of air emissions from groups of enterprises on the territory of industrial cities, zones with cumulative chemical pollution are created that cause significant harm to the health of residents of the Krasnoyarsk Territory.

Today, unfortunately, there is no practice in establishing sanitary protection zones for facilities and enterprises, including industrial hubs, local authorities of municipalities of the region, and there are no restrictions on the use of land by law and the introduction of appropriate regulation lines.

We will consider what measures are being taken to solve the problem of air pollution in the Krasnoyarsk Territory. Thus, on November 25, 2013 the program “Reducing the negative environmental impact of enterprises of the Krasnoyarsk Territory for 2014-2020” was approved.
The purpose of this program is to reduce the negative impact on the air, water bodies and land (environmental components) in the industrial centres of the Krasnoyarsk Territory. As part of this program, namely to solve Task 1 “Reducing the negative impact on atmospheric air by enterprises of the Krasnoyarsk Territory” subtask 1 “Reducing emissions of harmful (polluting) substances into the atmospheric air from stationary and mobile sources by enterprises of the Krasnoyarsk agglomeration”, the following measures are assumed:

- implementation of the project “Ecologically acceptable Soderberg technology” in the electrolysis enclosures of RUSAL Krasnoyarsk;
- increasing the efficiency of gas cleaning equipment of the calcining complexes of RUSAL Krasnoyarsk;
- sealing of pekopriemniki of RUSAL Krasnoyarsk;
- reconstruction of aspiration systems for jaw and hammer crusher in the Gorny workshop, Krasnoyarsk Cement Plant;
- reconstruction of the Volga-35 refrigerator with the installation of a bag filter in the Roasting Plant of the Krasnoyarsk Cement Plant;
- reconstruction of the conveyor aspiration system 9-10 at 11-12 of the Roasting workshop at Krasnoyarsk Cement Plant;
- reconstruction of the aspiration system of conveyors 11-12 to the warehouse of the Roasting workshop at Krasnoyarsk Cement Plant;
- installation of gas cleaning equipment in the production of sanitary and hygienic cabins, in workshops No 1 and No 2 of Alfa LLC and other activities.

As a result of the implementation of measures aimed at reducing emissions of harmful (polluting) substances into the air from stationary sources by enterprises of the Krasnoyarsk agglomeration, it is planned to reduce the gross emissions of harmful (polluting) substances from stationary sources of enterprises of the Krasnoyarsk Territory by 0.4% from 2011 levels year, or by 10.97 thousand tons by 2020.

Also in 2013, the state program of the Krasnoyarsk Territory “Environmental Protection, Reproduction of Natural Resources” was approved.

In subprogram No 7 “Air Protection, Environmental Monitoring” it is stated that in order to conduct state policy in the field of air protection in the Krasnoyarsk Territory, to achieve standards for maximum permissible emissions of harmful (polluting) substances and information exchange, there is interaction within the agreements between the Ministry, the Office of Rosprirodnadzor for the Krasnoyarsk Territory, the Office of Rospotrebnadzor for the Krasnoyarsk Territory and the organizations of the Krasnoyarsk region.

This subprogramme includes such activities as:

- measures to protect the environment and ensure environmental safety, aimed at regulating the quality of atmospheric air;
- provision of activities (provision of services) of subordinate institutions for the purpose of monitoring the state of the environment;
- measures to protect the environment and ensure environmental safety, as well as ensuring the activities (services) of subordinate institutions in order to inform the population, the executive authorities of the Krasnoyarsk Territory and local government about the state of the environment in the Krasnoyarsk Territory.

It is also important to note that at the end of 2018, Dmitry Kobylkin, Minister of Ecology of Russia, visited Krasnoyarsk with a working visit, checking the implementation of the federal program “Clean Air”, which includes comprehensive action plans to reduce emissions of pollutants into the
atmospheric air in large industrial centres. During the visit to CHP-3, the Minister inspected the environmental program of the Siberian Generating Company, which will reduce the emissions of heat sources and the index of atmospheric pollution in their zone of influence.

Thus, in November 2018, the city already implemented a program to replace low-efficient, non-environmentally friendly boiler houses and transfer their consumers to CHP plants equipped with modern environmental protection equipment and high chimneys. Moreover, Krasnoyarsk CHP-2 and CHP-3 already complied with these conditions at that time as they were equipped with electric filters with an efficiency of over 99%, but the environmental modernization of the first municipal heat and power plant started only in 2018.

By November 2018, the first chimney 105 meters high had been demolished at the station site and construction of a new one at least 270 meters high began. This will increase the efficiency of dispersion of flue gases in the upper atmosphere and significantly reduce the concentration of station emissions in the urban air. After commissioning of the new pipe at the Krasnoyarsk CHP-1, two more will be demolished - 105 and 120 meters high. The vacant space will be able to accommodate modern electrostatic precipitators, which will replace the existing cyclone battery catchers.

The cumulative expected environmental effect from the modernization of CHP-1 is a reduction in plant emissions by 25%, and from the replacement of boiler houses by 10.8 thousand tons a year and a decrease in the air pollution index in the places where they were located.

On the basis of operational information on air pollution in Krasnoyarsk, the following facts should be taken into account:

- In January 1, 2019, the level of air pollution in Krasnoyarsk is low. Excess of maximum permissible concentrations for the observed substances was not recorded.
- In February 1, 2019, the level of air pollution in Krasnoyarsk is low, in Pokrovka district it is rather high in nitrogen dioxide.
- According to the latest information, in March 1, 2019, the level of air pollution in Krasnoyarsk is low, and in Solnechnyi district, it is rather high in nitrogen dioxide.
- According to current information in April 1, 2019, the level of air pollution in Krasnoyarsk is low. Excess of maximum permissible concentrations for the observed substances was not recorded.
- In May 1, 2019, the level of air pollution in Krasnoyarsk is low. Excess on the observed substances is not recorded.

Further, we will present an analytical review of the state of air pollution in April 2019 in various districts of Krasnoyarsk. In April 2019, monitoring of air pollution was carried out using automatic gas analyzers: at automated observation posts (hereinafter - AOP) Krasnoyarsk-Severny, Krasnoyarsk-Solnechnyi, Krasnoyarsk-Cheryomushki and Krasnoyarsk-Pokrovka, Krasnoyarsk-Vetluzhanka through continuous registration of mass concentrations of oxide and nitrogen dioxide, sulfur dioxide, carbon monoxide, suspended particles; Krasnoyarsk-Vetluzhanka through continuous registration of mass concentrations of oxide and nitrogen dioxide, sulfur dioxide, carbon monoxide, ammonia, hydrogen sulfide, particulate matter.

The maximum values of one-time concentrations of pollutants are fixed:

- carbon monoxide - 1.1 MPCmr at Krasnoyarsk-Cheryomushki AOP (04/09/2019);
- nitric oxide - 0.8 MPCmr at Krasnoyarsk-Severny AOP (04/29/2019);
- ammonia - 0.09 MPCmr at Krasnoyarsk-North AOP (04.24.2019);
- hydrogen sulfide - 6.35 MPCmr at Krasnoyarsk-Pokrovka AOP (04/09/2019);
- hydrofluoride - 4.85 MPCmr at Krasnoyarsk-Severny AOP (23.04.2019);
- hydrochloride -10 MPCmr at Krasnoyarsk-Cheryomushki AOP (04/10/2019) and Krasnoyarsk-Pokrovka AOP (04/23/2019);
solid fluorides - 0.42 MPCmr at Krasnoyarsk-Severny AOP (23.04.2019);
formaldehyde - 0.86 MPCmr at Krasnoyarsk-Cheryomushki AOP (04/10/2019); benzene - 0.11 MPCmr;
phenol - 0.3 MPCmr at Krasnoyarsk-Pokrovka AOP (04/04/2019);
chlorobenzene - 0.02 MPCmr at Krasnoyarsk-Pokrovka AOP (04/04/2019, 04/06/2019);
ethylbenzene - 1.15 MPCmr at Krasnoyarsk-Zelenogorsk AOP (04/28/2019).

The largest number of cases of exceeding single concentrations of pollutants was observed: carbon monoxide - 1 case at Krasnoyarsk-Cheryomushki AOP, nitrogen dioxide - 14 cases at Krasnoyarsk-Pokrovka AOP, 59 hydrogen sulfide at Krasnoyarsk-Cheryomushki AOP, suspended particles (up to 2.5 μm) - 3 cases at Krasnoyarsk-Beryozovka AOP, hydrofluoride - 3 cases at Krasnoyarsk-Severny AOP and Krasnoyarsk-Solnechny AOP, and 15 cases at Krasnoyarsk-Pokrovka AOP. Excess of single concentrations of sulfur dioxide, nitrogen oxide, ammonia, solid fluorides, formaldehyde, benzene, o-xylene, styrene, toluene, phenol, chlorobenzene, ethylbenzene of 1 MPCmr was not recorded.

Researchers D V Goryaev and I V Tikhonova are right when they point out that the management of public health and the quality of the environment should be carried out on the basis of a comparative in-depth hygienic description of the dynamics of changes in environmental pollution levels using hygienic safety criteria, modern approaches and methods for assessing health risks to solve practical problems of maintaining public health and recovery environment [6].

In addition, we believe that to solve the problem of atmospheric air pollution in the Krasnoyarsk Territory it is necessary:

- to regulate emissions of pollutants into the air when adverse weather conditions take place;
- to normalize emissions into the air of pollutants on the basis of summary volumes of maximum permissible emissions for cities and industrial centres of the region;
- to reduce emissions of pollutants into the air from stationary sources due to technical re-equipment, modernization and reconstruction of production;
- to reduce air pollution from road transport through the development of urban planning regulation, public electric transport, as well as strengthening state control over emissions of harmful substances from transport and improving traffic management;
- to increase the effectiveness of state supervision in the field of air protection. We would like to note that an indicator of these measures should be a reduction of the negative impact on atmospheric air.

To implement these measures, in our opinion, it is necessary to do the following:

- to develop regulatory legal acts of the Krasnoyarsk Territory and organize work on the regulation of emissions, especially during those periods when adverse meteorological conditions are observed;
- to organize the development of summary volumes of maximum permissible emissions for cities and industrial centres of the region;
- to develop regulatory legal acts of the Krasnoyarsk Territory, which will regulate the use of summary volumes of maximum permissible emissions when the enterprises approve and agree on standards for maximum permissible emissions;
- to introduce resource and energy-saving technologies, use high-performance dust and gas cleaning systems;
- to close small heating boilers, boilers manufacturing enterprises;
- to replace diesel generator sets with gas generating stations in remote settlements of the Krasnoyarsk Territory;
• to use the world environmental standards of Euro-5 and Euro-6, as well as alternative fuels in the operation of road transport;
• to develop public transport, including its electric types (underground, trolleybus network, network of high-speed tram lines, etc.);
• to use natural gas as a fuel for municipal transport in large cities of the region;
• to improve the organization of traffic, as well as methods of urban planning regulation;
• to strengthen the supervision of the protection of atmospheric air to comply with the standards for the content of harmful substances in the exhaust gases of road transport;
• to create a network of green urban areas, continuous transport infrastructure, as well as other conditions for the development of non-motorized, environmentally friendly modes of transport in the cities of the region.

In conclusion, we consider it appropriate to note that sustainable development of the Krasnoyarsk Territory, high quality of health and life of the regional population can be ensured only if the corresponding state of the environment is maintained. The environment must be included into the system of socio-economic relations as one of the most valuable component of the national wealth. The formation and implementation of the regional socio-economic development strategy and the state regional policy in the field of environmental protection and environmental safety should be interconnected, since the health, environmental safety and social well-being of the population are indisputably in unity.

References
[1] Klyuev N N and Yakovenko L M 2018 "Dirty" cities of Russia: the factors defining pollution of atmospheric air Bulletin of Peoples’ Friendship University of Russia. Series: Ecology and health and safety 26(2) 237-50
[2] Lepikhin A M, Moskvichev V V, Nicheporchuk V V and Simonov K V 2010 The concept of assessment of environmental risk on the example of Krasnoyarsk Krai Security concern and emergency situations 1 31-42
[3] Badmayeva S E and Zimmerman V I 2015 Anthropogenic pollution of atmospheric air of the cities of Krasnoyarsk Krai Bulletin of the Krasnoyarsk state agricultural university 2 27-32
[4] State report 2018 About a state and environmental protection in Krasnoyarsk Krai in 2017 (Krasnoyarsk)
[5] Hramova L N, Efits O A and Romantsova N F 2017 Ecology of Krasnoyarsk Krai: studies (Krasnoyarsk: Siberian federal university)
[6] Goryaev D V and Tikhonova I V 2016 Hygienic assessment of quality of atmospheric air and risks for health of the population Risk analysis to health 2 76-83