

HYGIENIC ASSESSMENT OF ATMOSPHERIC AIR IN KUZBASS INDUSTRIAL CENTERS AS PART OF THE "CLEAN AIR" FEDERAL PROJECT

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Novokuznetsk and Kemerovo, major industrial centers in Kuzbass, participate in the "Clean Air" federal project. Since 2018 and 2023, respectively, they have been implementing Comprehensive Action Plans devised to decrease contaminating emissions and thus improve the quality of the air and the quality of life of the population. The Plans are part of the "Ecology" national project. This study aimed to hygienically assess the quality of atmospheric air as part of the implementation of the "Clean Air" federal project, which involves improving the air monitoring system in the industrial centers of Kuzbass. Hazard identification and assessment of exposure levels were performed using the methodology provided in MR (methodological recommendations) 2.1.6.0157-19. In Novokuznetsk, air pollutant emissions decreased by 18.1%, while in Kemerovo they increased by 12.4%. The atmospheric pollution index was rated as "extremely high" and "high", respectively. As part of the study, we evaluated the spatial relationship between stationary and route air quality monitoring stations, identified emission impact zones for major industrial complexes, assessed the rationality of observation point locations, and implemented the necessary adjustments. Improving air quality monitoring will make it possible to obtain adequate and timely information on air quality and develop measures to improve the living environment and public health

Keywords: clean air, stations and monitoring program, emission dynamics, air quality monitoring, priority pollutants, air pollution index

Author contribution: Bachina AV — study concept and design, analysis and interpretation of the results; Koskina EV — study concept and design, manuscript writing and editing; Glebova LA — data acquisition, analysis and interpretation of the results.

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ГИГИЕНИЧЕСКАЯ ОЦЕНКА РЕАЛИЗАЦИИ ФЕДЕРАЛЬНОГО ПРОЕКТА «ЧИСТЫЙ ВОЗДУХ» В ПРОМЫШЛЕННЫХ ЦЕНТРАХ КУЗБАССА

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Крупные промышленные центры Кузбасса — города Новокузнецк и Кемерово являются участниками федерального проекта «Чистый воздух». С 2018 и 2023 гг. соответственно в них реализуют Комплексные планы мероприятий по снижению выбросов загрязняющих веществ, направленные на повышение качества воздушной среды и жизни населения, предусмотренные национальным проектом «Экология». Целью исследования было выполнить гигиеническую оценку атмосферного воздуха в рамках реализации мероприятий федерального проекта «Чистый воздух» для совершенствования системы мониторинга воздушной среды промышленных центров Кузбасса. Проведены оценка динамики выбросов загрязняющих веществ, анализ результатов измерений атмосферного воздуха на 16 стационарных постах. Идентификацию опасности и оценку уровней формируемой экспозиции выполняли с использованием методических подходов МР 2.1.6.0157-19. В г. Новокузнецке объем выбросов загрязняющих веществ в атмосферный воздух снизился на 18,1%, а в г. Кемерово — увеличился на 12,4%. Индекс загрязнения атмосферы оценен как «чрезвычайно высокий» и «высокий» соответственно. Оценено взаимное расположение стационарных и маршрутных постов наблюдения качества атмосферного воздуха, определены зоны влияния выбросов ведущих предприятий, дана оценка рациональности расположения точек наблюдения, внесены необходимые коррективы. Совершенствование мониторинга воздушной среды позволит получать адекватную и своевременную информацию о качестве атмосферного воздуха и разрабатывать мероприятия по улучшению среды обитания и здоровья населения.

Ключевые слова: чистый воздух, посты и программа наблюдения, динамика выбросов, мониторинг качества атмосферного воздуха, приоритетные загрязнители, индекс загрязнения атмосферы

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Maintaining the health and increasing the life expectancy of the population are strategic objectives of the state. It has been proven that atmospheric air pollution in urban areas leads to increased morbidity, mortality, and disability due to cardiovascular diseases, cancer, and other conditions. [1, 2].

The need to improve the general environment and, consequently, to enhance the medical and demographic situation in cities with high levels of anthropogenic pollution justified the development and implementation of the Clean Air federal project. One of the project's targets reflecting realization of the Russian

Federation Presidential Decree is to reduce emissions of dangerous pollutants in large industrial centers by at least 20% of the total volume [3–5].

The achievement of such targets is especially important in regions like Kuzbass (the Kemerovo region), where the concentration of coal-chemical plants, mechanical engineering factories, and thermal power facilities is among the highest in the country. Kuzbass accounts for a significant volume of coal mining and processing, as well as the production of rolled ferrous metals, ferrosilicon, and railway main rails. In large industrial agglomerations such as Novokuznetsk and Kemerovo, emissions from major plants and factories have resulted in high levels of anthropogenic pollution, including severe air contamination. The results of tests and studies indicate that in regions where the condition of air is unsatisfactory, the population's quality of life and life expectancy decline [6, 7].

The climate in the Kemerovo region is severely continental, characterized by significant annual and daily temperature fluctuations, frequent inversions, predominantly low atmospheric pressure, and weak winds combined with intense seasonal solar radiation, which contribute to the formation of photochemical smog. The weather conditions promote dispersion of the contaminants for up to 100 days a year, and the negative consequences of this factor are especially pronounced in industrial centers [8]. The primary reason for this situation is the location of these centers in the Kuznetsk Basin — in the southwestern part of Western Siberia — and their proximity to the junction of the Kuznetsk Depression with the mountain ranges of the Kuznetsk Alatau, Gornaya Shoria, and Salair. Thus, the climatic and geographical features of Kuzbass create conditions that prevent the dispersion of pollutants in the atmospheric air [9].

Another aggravating factor lies in historical urban planning: in the industrial cities of Kuzbass, plants and factories were often situated in close proximity to residential districts. The high concentration of numerous pollution sources within a relatively small area, combined with the insufficient effectiveness of current technological and sanitary measures, highlights the urgent need to develop and implement comprehensive plans to protect atmospheric air and assess the effectiveness of these measures.

The current key scientific and practical tasks include assessing the zone of influence and spatial distribution of industrial pollutant emissions, optimizing control measures, and creating a reliable air quality monitoring system focused on substances that negatively affect public health. The particularly important activities are assessing the relative locations of stationary and route monitoring posts, identifying priority pollution components, determining exposure areas where concentrations pose the greatest risk to human health, and locating areas most unfavorable for living [10, 11].

Consequently, the enhancement of atmospheric air quality and the development of improved hygienic assessment methods are essential for the successful implementation of the federal project "Clean Air" [12, 13].

This study aimed to hygienically assess the quality of atmospheric air as part of the implementation of the "Clean Air" federal project, which involves improving the air monitoring system in the industrial centers of Kuzbass.

METHODS

This study focused on the cities of Novokuznetsk and Kemerovo of the Kemerovo region, which are the priority locations in terms of atmospheric air pollution. Kemerovo, with a population of 542,928 and an area of 294.8 km², is a major chemical

industry center and the most densely populated city of the Region. The key chemical plants and factories of Kemerovo are Azot, which produces ammonium nitrate, nitric acid, caprolactam, and Khimprom, which specializes in chlorine products (chlorine, hydrochloric acid, caustic soda) and organic synthesis (polyesters, polypropylene glycol).

Novokuznetsk, with a population of 546,951 and an area of 424.27 km², is one of the largest industrial centers in Russia. The city is a metallurgical production and coal mining hub; its industrial complex includes an integrated metallurgical works, ferrous and non-ferrous metallurgy plants, coal mines, and thermal power plants.

The methodological approaches developed for the "Clean Air" federal project underpinned the assessment of the sanitary and epidemiological factors influencing atmospheric air quality and its impact on public health, and supported the development of measures to reduce emissions and enhance the existing monitoring network [14–16].

The hygienic assessment included the analysis of social and hygienic monitoring data collected from 2017 to 2024, i.e., from the beginning of the implementation of the "Clean Air" federal project. The data included information about pollutant emission sources, their parameters and spatial characteristics, as well as exposure levels specified in the draft standards regulating maximum permissible emissions (MPE) of pollutants into the atmosphere, which are part of the comprehensive emission quota plan.

The assessment of air pollutant emission dynamics was based on materials from a report by the Ministry of Natural Resources and Ecology of Kuzbass [17].

For hygienic assessment of the atmospheric air quality, we used the results of instrumental observations from stationary posts set up by the Hydrometeorology and Environment Monitoring Center, which is a branch of the West Siberian Territorial Hydrometeorology and Environment Monitoring Administration. There are eight such stationary posts in every city; they are linked into a state monitoring network. The monitoring program included registration of the amounts of the key atmospheric air pollutants and marker substances specific to a particular production process, characterizing its features. Instrument readings were taken every 20 minutes.

In Novokuznetsk, automatic devices continuously monitored a number of substances, including suspended solids, nitrogen dioxide, carbon monoxide, sulfur dioxide, black carbon (soot), phenol, formaldehyde, lead, nitrogen oxide, ozone, ammonia, hydrogen sulfide, suspended particles PM_{2.5} and PM₁₀. The samples were collected in standard mode, according to the full program, at 01:00, 07:00, 13:00, and 19:00 local time.

In Kemerovo, the samples were taken at stationary posts according to an abridged monitoring program at 07:00, 13:00, and 19:00 local time. The list of controlled substances included hydrogen fluoride, hydrogen cyanide, suspended solids, nitrogen dioxide, carbon monoxide, sulfur dioxide, black carbon (soot), phenol, formaldehyde, and lead.

Hygienic assessment of the level of atmospheric air pollution in the considered cities involved a comparison of the concentrations registered at the observation posts with the maximum permissible concentrations approved in SanPiN 1.2.3685-21 "Hygienic standards and requirements for ensuring the safety and (or) harmlessness of environmental factors for humans". The values from a single sample were compared with the maximum permissible single concentrations (MPC_s), while the daily mean values were compared with the maximum permissible average daily concentrations (MPC_{ad}). The average annual concentration was calculated after each year of the observation

Table 1. Dynamics of pollutant emissions into the atmosphere from stationary sources in the cities of Kemerovo and Novokuznetsk (thousand tons per year)

Territory	2017	2018	2019	2020	2021	2022	2023	2024
Novokuznetsk	313.331	295.794	294.195	277.528	268.297	263.211	260.971	256.683
Kemerovo	41.106	36.111	55.834	52.542	45.947	65.053	57.033	59.08

period; the values were compared with the maximum permissible average annual concentration (MPC_{aa}), since as a minimum, each post collected over 300 samples of every monitored substance.

To determine the degree of pollution, we calculated the atmospheric air contamination index (ACI): the sum of the mean annual concentrations (in fractions of MPC, with the correlation of the hazard class of each pollutant with the hazard class of sulfur dioxide) of the five pollutants that contaminated the city's air the most.

Based on the calculation of the total hazard coefficient in accordance with MR 2.1.6.0157-19, we conducted a spatial analysis of the influence of Novokuznetsk plants on the residential areas. The analysis yielded an assessment of the relative locations of the route and stationary observation posts and the city's industrial facilities. The spatial analysis was carried out using the ArcGIS software (ESRI; USA) (license agreement No. 2010RUS7342).

The calculations were performed in MS Excel 2016 (Microsoft, USA); we calculated the sum, the mean values, and the trends.

RESULTS

The comprehensive action plan to reduce pollutant emissions into the atmosphere of Kemerovo and Novokuznetsk aims to achieve targets for air quality and ensure favorable living conditions for residents.

The program and the action plan under the "Clean Air" federal project are based on integrated approach that includes technological, sanitary, urban planning, and organizational measures. In particular, for Kemerovo and Novokuznetsk, the "Clean Air" federal project envisages the following: modernization of the transport rolling stock and its conversion to environmentally friendly fuels; introduction of new technological and production solutions, including effective dust and gas purification methods and facilities; gasification of the single-family neighbourhoods, demolition of dilapidated housing, modernization and overhaul of thermal power facilities; optimization of atmospheric air quality monitoring, including modernization of the existing monitoring network, expansion of social and hygienic monitoring, advanced automation of data control, re-equipment of the laboratories subordinate to Rospirodnadzor and Rospotrebnadzor.

According to the regional Ministry of Ecology and Natural Resources, 24 measures are being implemented. In Kemerovo, the plan is to reduce the total volume of atmospheric air emissions by 88.165 thousand tons by 2036, which would result in a two-fold decrease compared to 2020. By the end of 2026, Novokuznetsk's total atmospheric emissions will decrease by 83.769 thousand tons, or 25.1% of the 2017 level. The reduction in total emissions of pollutants by the end of 2026 will amount to 51.069 thousand tons — 59.5% of the 2017 level.

In addition, Rospirodnadzor has approved a list facilities for which a quota is set. These facilities contribute the most to the contamination of atmospheric air; under this initiative, they will be given the maximum permissible emission values and long-term action plans to achieve them.

In the Kuzbass industrial centers, industrial facilities and utilities infrastructure were responsible for 78–94% of air pollution.

The share of autonomous heat supply sources (in private residencies) was 6–21%, and that of motor transport did not exceed 0.5%. In single-family residential areas, emissions are released at low altitudes, creating a risk of pollution in the surface layer of the atmosphere that directly affects residents. The situation is worsened by unfavorable meteorological conditions that hinder the dispersion of pollutants, especially during the cold season, when a "black sky" effect occurs and negatively affects public health.

Through the period of implementation of the "Clean Air" federal project in Novokuznetsk, the volume of pollutants released into the atmosphere from stationary sources decreased by 56.6 thousand tons (18.1%). In particular, the emissions of solids went down by 13.6 thousand tons (37.7%), liquid gaseous substances — by 43 thousand tons (15.5%), including sulfur dioxide — by 21.7 thousand tons (38.7%), carbon monoxide — by 31.7 thousand tons (11.0%), nitrogen dioxide — by 3.3 thousand tons (18.8%) (Table 1).

For Kemerovo, 2020 was taken as the baseline year against which emission trends were assessed. The volume of pollutants released into the atmospheric air from stationary sources increased by 6.5 thousand tons (12.4%) in 2024. The specific growth was as follows: solids — by 3.9 thousand tons (39.1%), liquid gaseous substances — by 2.6 thousand tons (6.2%), including carbon monoxide — by 0.8 thousand tons (5.7%), nitrogen dioxide — by 2.0 thousand tons or 18.0%.

Summary calculations of atmospheric air pollution were made for Novokuznetsk and Kemerovo, and the priority pollutants included in the monitoring program were identified.

In 2024, 1106386 measurements of atmospheric air pollutants were carried out at stationary posts in Novokuznetsk. Of these, 13654 samples did not meet the hygiene standards, which amounted to 1.23%. Regarding single concentrations, hydrogen sulfide and carbon monoxide exceeded the MPC_s by a factor of 5, while nitrogen dioxide, nitric oxide, ammonia, suspended solids, formaldehyde, and fluorinated gaseous compounds exceeded them by a factor of 2 to 5.

In Kemerovo, stationary monitoring posts made 56529 air pollution measurements; 217 samples (0.38%) had the content of contaminants exceeding the MPC. Among the single concentrations, no exceedance of 5 or more MPC_s was recorded; exceedances of 2 to 5 MPC_s were observed for nitrogen dioxide, suspended solids, formaldehyde, and phenol (Table 2).

An assessment of atmospheric air pollution levels in populated areas showed that, at stationary monitoring posts in Kemerovo, the air was most contaminated with benz(a)pyrene and formaldehyde, whose average annual concentrations exceeded the maximum permissible concentrations (MPC_{aa}) by 2.6–3.1 and 2.0–2.6 times, respectively. In 2024, compared to 2017, the average annual concentration of ammonia in the atmosphere increased by 30%, nitrogen (II) oxide by 9.5%, carbon monoxide by 5.3%, and formaldehyde by 28.3%. The levels of some contaminants decreased during this period: hydrogen chloride by 60.0%, black carbon (soot) by 66.7%, phenol by 30.0%, hydrogen cyanide by 20.0%, and benzo(a)pyrene by 16.1% (Table 3).

In Kemerovo, the ACI calculation took into account the concentrations of five priority pollutants: benz(a)pyrene, suspended solids, formaldehyde, nitrogen dioxide, and ammonia.

Table 2. Some indicators of atmospheric air pollution registered at stationary posts in Kemerovo and Novokuznetsk (2024)

Pollutants	Novokuznetsk					
	Number of single samples, average monthly	% exceeding the MPC	Maximum concentration among single samples	The order of MPC _s exceedance	Mean concentration, daily average	The order of MPC _{ad} exceedance
Nitrogen dioxide	104253	0.72	0.56	2.82	0.029	0.71
Ammonia	10423	0.0029	0.7	3.5	0.0086	0.22
Benz(a)pyrene*	–/36	–/80.56	0.000039	–	0.0000063	6.31
Suspended substances	9348	0.28	1.35	2.7	0.094	1.25
PM10 suspended particles	28693	0.035	1.2	4	0.038	0.95
PM2.5 suspended particles	28693	1	0.29	1.83	0.03	1.2
Ozone	91338	1.19	0.29	1.84	0.04	1.33
Hydrocyanide	2338	–	0.035	–	0.0012	0.012
Manganese and its compounds	–/24	–/0.00	0.00006	0.006	0.000025	0.025
Hydrogen sulfide	198947	5.03	0.04	5	0.0022	1.1
Sulfur dioxide	205190	0	0.3	0.6	0.0027	0.05
Carbon monoxide	206901	0.3	44.5	8.9	0.59	0.2
Phenol	7016	0.01	0.011	1.1	0.00085	0.28
Formaldehyde	7016	2.27	0.16	3.14	0.012	3.88
Fluoride gaseous compounds	8185	0.78	0.041	2.05	0.0017	0.34
Nitrogen oxide	104238	0.63	0.92	2.29	0.03	0.5
TOTAL	1106386/60	1.23/48.3				
Kemerovo						
Nitrogen dioxide	6998	0.51	0.557	2.79	0.038	0.95
Nitrogen oxide	4375	0.11	0.5	1.25	0.023	0.38
Ammonia	6994	0.41	0.33	1.65	0.039	0.98
Benz(a)pyrene*	–/36	–/41.67	0.000012	–	0.0000026	2.6
Suspended substances	5964	0.72	1.052	2.1	0.057	0.76
Hydrochloride	2617	0.08	0.31	1.55	0.008	0.4
Hydrocyanide	2623	–	0.04	–	0.0008	0.08
Lead	–/36	–/0.0	0.00004	–	0.000001	0.003
Sulfur dioxide	3510	0	0.067	0.13	0.0026	0.05
Carbon	5088	0	0.15	1	0.003	0.12
Carbon monoxide	6993	0.51	9.4	1.88	1	0.33
Phenol	6120	0.1	0.032	3.2	0.0007	0.23
Formaldehyde	5247	1.14	0.176	3.52	0.0077	2.57
Chrome (VI)	–/36	–/0.00	0.00001	–	0.000001	0.00067
TOTAL	56529/108	0.38/14.8				

In 2017, the value of the index was 10.85, and in 2024 — 10.34, classified as "high." The rate of decline was 4.6%.

In Novokuznetsk, data from stationary observation posts on the average annual concentrations of air pollutants showed that benz(a)pyrene exceeded the MPC_{aa} by 6.0–6.3 times, formaldehyde by 1.7–4.0 times, suspended solids by 1.2–1.5 times, and ozone by 1.3 times. Compared to 2017, in 2024 the air had significantly higher concentrations of hydrogen sulfide (a 4.0-fold increase), nitrogen oxide (a 3.0-fold increase), formaldehyde (a 2.4-fold increase), and hydrocyanic acid (a 20% increase). The concentration of the following substances decreased during the study period: ammonia — by 78.5%, sulfur dioxide — by 73.0%, phenol — by 71.7%, carbon monoxide — by 60.7%, fluorinated gaseous compounds — by 43.3%, and suspended solids — by 15% (Table 3).

In Novokuznetsk, the ACI calculation too into account the concentrations of five priority pollutants: benz(a)pyrene, suspended solids, formaldehyde, nitrogen dioxide, and hydrogen sulfide. During the study period, the value of the index increased from 14.9 to 19.3 (a 1.3-fold increase) and was classified as "extremely high." A marked increase in the surface concentration of hydrogen sulfide — a substance that not only produces an unpleasant odor but can also cause respiratory damage, sometimes moderate or severe — has raised significant concern.

The industrial facilities contributing to atmospheric air pollution underwent a hazard identification procedure, and total normalized hazard coefficients were calculated for each plant and factory. In Novokuznetsk, a subsequent ranking identified four industrial complexes with the greatest impact of emissions

Table 3. Dynamics of average annual concentrations of atmospheric air pollutants as registered at the stationary posts in Kemerovo and Novokuznetsk

Pollutants	Hazard class	MPC _{aa} ^a mg/m ³	Average annual concentration, mg/m ³		The order of MPC _{aa} exceedance		Growth rate in 2024 vs. 2020, %
			2020	2024	2020	2024	
Kemerovo							
Suspended substances	3	0.075	0.06	0.057	0.80	0.76	−5.0
Hydrochloride	2	0.02	0.02	0.008	1.00	0.40	−60.0
Ammonia	4	0.04	0.03	0.039	0.75	0.98	+30
Nitrogen (II) oxide	3	0.06	0.021	0.023	0.35	0.38	+9,5
Sulfur dioxide	3	0.05	0.007	0.0026	0.10	0.05	−62.8
Carbon monoxide	4	3	0.95	1.00	0.32	0.33	+5.3
Carbon black (soot)	3	0.025	0.009	0.003	0.13	0.12	−66.7
Nitrogen (IV) oxide	3	0.04	0.04	0.038	0.75	0.95	−5.0
Phenol	2	0.003	0.001	0.0007	0.33	0.23	−30.0
Formaldehyde	2	0.003	0.006	0.0077	1.67	2.57	+28.3
Hydrocyanide	2	0.01	0.001	0.0008	0.06	0.08	−20.0
Benz(a)pyrene	1	0.000001	0.0000031	0.0000027	3.00	2.70	−16.1
Novokuznetsk							
Suspended substances	3	0.075	0.11	0.09	1.5	1.20	−15
Hydrocyanide	2	0.01	0.001	0.0012	0.1	0.12	+20
Ammonia	4	0.04	0.04	0.0086	1.0	0.22	−78.5
Nitrogen (II) oxide	3	0.06	0.01	0.03	0.17	0.50	+200
Sulfur dioxide	3	0.05	0.01	0.0027	0.20	0.05	−73.0
Hydrogen sulfide	2	0.002	0.0005	0.0022	0.25	1.10	+340
Carbon monoxide	4	3	1.5	0.59	0.50	0.20	−60.7
Ozone	1	0.03	–	0.04	–	1.33	–
Nitrogen (IV) oxide	3	0.04	0.03	0.029	0.75	0.73	−3.3
Phenol	2	0.003	0.003	0.00085	1.00	0.28	−71.7
Formaldehyde	2	0.003	0.005	0.012	1.7	4.00	+140
Fluoride gaseous compounds	2	0.005	0.003	0.0017	0.60	0.34	−43.3
PM10 suspended particles		0.04	–	0.038	–	0.95	–
PM2.5 suspended particles		0.025	–	0.03	–	1.20	–
Benz(a)pyrene	1	0.000001	0.000006	0.0000063	6.00	6.30	+5

on public health — EVRAZ ZSMK, RUSAL Novokuznetsk Aluminum Plant, Kuznetskiye Ferrosplavy, and Kuznetskaya TPP. In Kemerovo, there are six such complexes: Koks, Azot, Kemerovskaya GRES, Khimprom, Novo-Kemerovskaya TPP. All these facilities are included in the Comprehensive Action Plan for the long-term reduction of air pollution in Kemerovo and Novokuznetsk until 2026 and 2036, respectively. The Plan is part of the "Clean Air" federal project.

Currently, the atmospheric air quality monitoring network covers 90% of the residential areas of the studied urban agglomerations. The implementation of the "Clean Air" federal project began earlier in Novokuznetsk than in Kemerovo; therefore, the data collected in Novokuznetsk were used to assess the relative locations of stationary and route atmospheric air quality monitoring posts. Based on the spatial distribution of the total hazard coefficient shaped by industrial emissions, we determined the respective exposure zones (Fig.). It has been established that residential areas within the exposure zones are mainly controlled by the stationary and route observation posts. However, given the prevailing winds, some territories are not covered by the air quality monitoring network.

An assessment of the rationality of the locations of stationary and route observation posts (based on spatial analysis) showed that the distance between them is less than 2 km; it is feasible

to increase this distance and establish additional posts in the pollution exposure zones.

DISCUSSION

It has been established that the atmospheric air of the industrial centers of Kuzbass contains substances with unidirectional effects that, under certain conditions, can negatively affect the health of the population. For example, suspended solids, nitrogen oxides, sulfur dioxide, hydrogen sulfide, phenol, formaldehyde, and carbon can cause respiratory diseases, while phenol and formaldehyde may also lead to visual impairments [18, 19].

The results of this study indicate the need to optimize the monitoring posts placement system and assess the spatial distribution of exposure levels as well as risks to public health. Significant air pollution registered by the observation posts is the reason for the deployment of extra posts in the cities; generally, the posts can collect and report the data for evaluation of the sanitary and hygienic situation in the areas where adequate field observations are unavailable. Determining where to place observation posts, refining the existing monitoring system, and establishing an effective observation program are urgent tasks [19, 20].

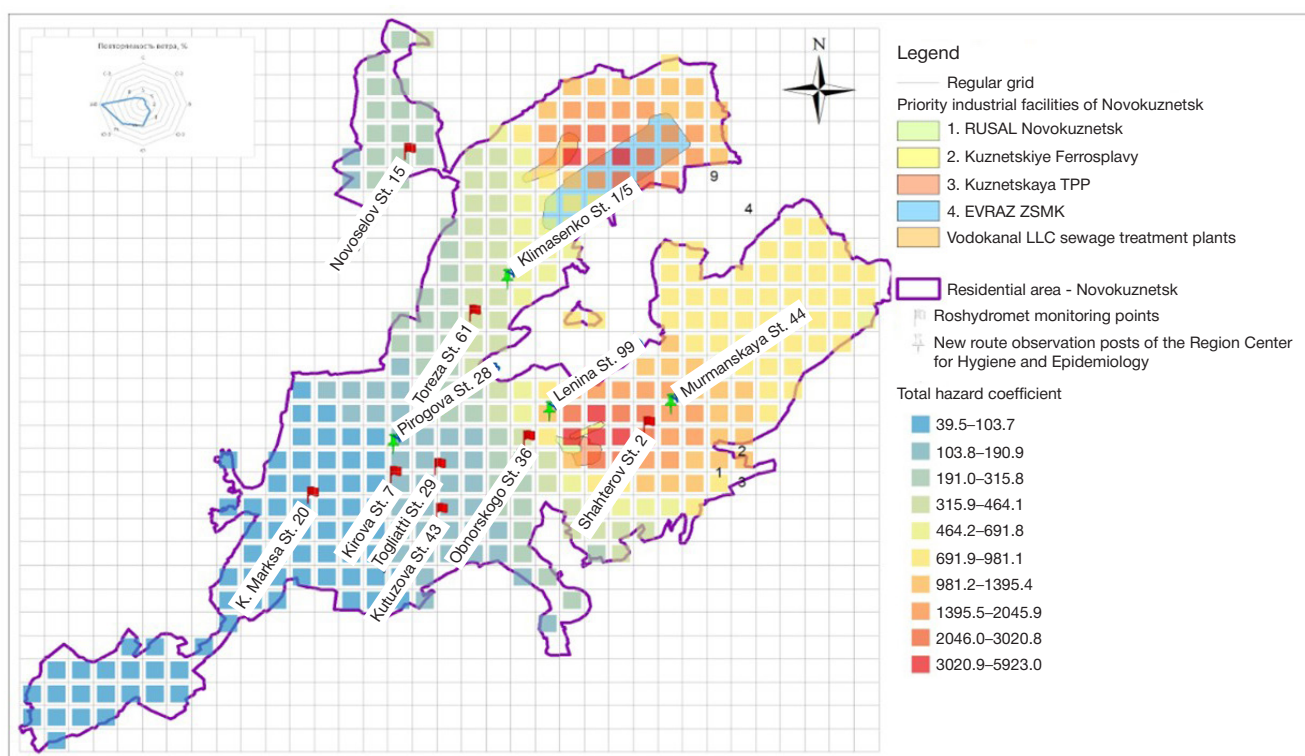


Fig. Spatial distribution of the total hazard coefficient by city's industrial facilities and relative to route and stationary posts

Given the significant contribution of autonomous (household) heating systems to overall air pollution, and taking into account the level of gas supply in the studied agglomerations (one of the lowest in Kuzbass and Siberia in general), it is advisable to consider expanding the comprehensive emission reduction plan to include measures for extending mainline gas service to single-family residential neighborhoods [21, 22].

Managerial decisions concerning environmental protection and public health are guided by monitoring data, and high pollution levels make it increasingly urgent to assess how effective planned air protection measures will be. At the same time, the most important aspect of such an assessment should be evaluating whether the programs and action plans are adequate for achieving the desired improvements in population health [23].

CONCLUSIONS

A hygienic assessment of air pollution in Kuzbass industrial centers found that, during the study period, emissions from stationary sources decreased by 18.1% in Novokuznetsk

and increased by 12.4% in Kemerovo. The atmospheric pollution index was rated as "extremely high" and "high", respectively.

The study provides a rationale for selecting priority atmospheric air pollutants to monitor. We identified hazards, and found the facilities emitting substances that harm population's health the most. These facilities have been included in the Comprehensive Action Plan of the "Clean Air" federal project.

In Novokuznetsk, we evaluated the relative locations of stationary and route air quality monitoring posts, identified the zones exposed to emissions from the leading plants, and assessed the rationality of the observation point locations.

Taking into account the negative impact of emissions from industrial complexes, it is recommended to set up additional monitoring posts and to increase the distance between the existing stationary and route posts.

As part of the implementation of the "Clean Air" federal project, a hygienic assessment was conducted, and measures were developed to improve the air quality control system under changing sanitary and epidemiological conditions, as well as to ensure the timely collection of information on pollution levels in Kuzbass's industrial centers.

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