Air pollution in the cities in Asian Russia: problems and prospects

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Abstract. In this article, we look at the issue of air pollution in cities in the Asian part of Russia, which are the industrial centres of the regions. Air pollution is shaped by a number of factors, including natural ones. In recent years, studies have been carried out in Russia and in foreign countries to determine the impact of pollutants emitted into the atmospheric air. There is a direct correlation between the state of public health and the amount of pollutants in the atmospheric air. Exceeding the maximum allowable concentrations in the air of territories threatens the life and health of people living in them. We have looked at the level of air pollution in cities, including the most polluted ones, and the measures taken by the government and large companies to mitigate the negative effects.

1. Introduction
Elevated concentrations of pollutants in the atmosphere, formed by sources on the territory of cities, are noted more often in the cold season. This is caused both by the use of coal as fuel for heating facilities and by regional climatic and geographical peculiarities. The main contribution to gross emissions on the territory is made by stationary sources of fuel and energy complex enterprises, numerous small boilers and stove heating of the private sector.

Many studies confirm a direct link between a number of diseases and air pollution. Most pollutants are invisible to the naked eye and can only be detected by laboratory tests. Therefore, air pollution is only felt by the population when there is a noticeable deterioration in health.

Masses of emitted hazardous substances entering the atmosphere from anthropogenic sources mix, move and precipitate out of it, polluting soil, water and living organisms. Photochemical processes are constantly taking place in the air basin, resulting in new compounds, sometimes more harmful than the original ones.

The priority list of cities with the highest level of air pollution in 2020 includes 15 cities with a total population of 1.8 million people (Table1). This list includes the cities where the Common Air Quality Index (AQI) reached or exceeded 14 [1].

When forming the list of the cities the indicators characterizing the level of short-term exposure to polluted air (ERR – ratio of the number of exceedances of MACr) were also taken into account. All 15 cities are located in the Asian part of Russia.
Table 1. Cities with the highest level of air pollution (AP) and substances that determined it in 2020.

| City        | Main pollutants* | City       | Main pollutants                      |
|-------------|------------------|------------|--------------------------------------|
| Vikhorevka  | BP, SP, NO₂, CO, SO₂ | Ulan-Ude  | BP, PM₂.₅, PM₁₀, SP, NO₂              |
| Zima        | BP, NO₂, FA, HCl, CO | Usolye-Sibirskoye | BP, NO₂, FA, SP, SO₂                  |
| Kansk       | BP, SP, NO₂, NO, SO₂ | Chermekhovo | BP, NO₂, SP, SO₂, NO                  |
| Kyzyl       | BP, SP, NO₂, FA, carbon (soot) | Chernogorsk | BP, NO₂, FA, SP, CO                   |
| Minusinsk   | BP, NO₂, FA, SP, CO | Chita      | BP, O₃, SP, NO₂, phenol               |
| Norilsk     | SO₂, CO, NO₂, SP, BP | Shelekhov | BP, O₃, NO₂, SP, PM₁₀                |
| Svirsk      | BP, SP, NO₂, SO₂, CO | Yuzhno-Sakhalinsk | FA, BP, NO₂, carbon (soot), SP       |
| Selenginsk  | BP, PM₂.₅, PM₁₀, SP, O₃ |           |                                      |

*hereinafter pollutants with highest exceedances are marked in bold.

BP – benzo(a)pyrene, SP – suspended particles, PM – suspended particles of PM₁₀ and PM₂.₅ fractions, F – formaldehyde, CO – carbon oxide, HCl – hydrogen chloride, NO₂ – nitrogen dioxide, NO – nitrogen oxide, O₃ – ground-level ozone, SO₂ – sulfur dioxide. The substances with the highest contribution to the AP level are in bold.

The significant release of hazardous substances is worsened by the frequent occurrence of adverse meteorological conditions in which pollutants remain suspended in the air for long periods of time. The need to radically improve the quality of air in large cities is admitted at the level of the Russian Government [2]. The “Clean Air” federal project as part of the national project “Ecology” is designed to improve the environmental situation in 12 major industrial centres, namely the cities of Bratsk, Krasnoyarsk, Lipetsk, Magnitogorsk, Mednogorsk, Nizhny Tagil, Novokuznetsk, Norilsk, Omsk, Chelyabinsk, Cherepovets and Chita.

2. Materials and methods

Considering the lack of a unified database of parameters of pollutant emissions sources, we used data from the Federal Service for Hydrometeorology and Environmental Monitoring (Rosgidromet), the Federal State Statistics Service (Rosstat), materials of the federal project “Clean Air” (hereinafter – The Federal Project) as part of the national project “Ecology”; we also used Russian regulatory documents, including Integrated Action Plans to Reduce Emissions of Air Pollutants.

Table 2. Characteristics of the level of air pollution in the territories of the regions of Asian Russia from 2016-2020 [3].

|                       | 2016 | 2017 | 2018 | 2019 | 2020 |
|-----------------------|------|------|------|------|------|
| Cities with stations  | 93   | 92   | 92   | 92   | 92   |
| Number of stations    | 239  | 239  | 239  | 239  | 241  |
| AQI>7                 | 37   | 37   | 38   | 36   | 29   |
| Q> MAC                | 77   | 78   | 72   | 67   | 65   |
| SI >10                | 31   | 30   | 31   | 30   | 27   |
| ERR >20               | 9    | 3    | 5    | 9    | 6    |

The level of air pollution is assessed based on a comparison of actual concentrations with sanitary and hygienic standards – MAC, which is maximum allowable concentration of a pollutant for residential areas, established by the Chief Sanitary Doctor of the Russian Federation. Average concentrations of pollutants are compared with daily average MAC (MACDA) and annual average MAC (MACAA); and maximum one-time concentrations are compared with maximum allowable one-time concentrations (MAC₇) [1].
Air quality indicators used in the study:

AQI – Common Air Quality Index, is calculated on the basis of the annual average concentrations of priority pollutants in each city. The indicator describes the level of chronic, long-term air pollution.

SI – standard index, the highest measured one-time concentration of a pollutant divided by the MAC_T. Determined from observation data at a station for a single pollutant, or at all stations in the area under consideration for all pollutants per month or per year. The number of cities with SI>5 or SI>10 is given below;

ERR – ratio of the number of exceedances of MAC_T to the total number of measurements per year at all monitoring stations for one pollutant, %.

According to existing assessment methods, air pollution is considered low when AQI is less than 5, high when AQI is 5-6, SI<5, ERR<20%, high if the AQI is 7 to 13, SI is 5 to 10, ERR is 20 to 50%, and very high if the AQI is 14 or more, SI>10, ERR>50%.

Table 3. Dynamics of air pollution in 2017-2020 and the main pollutants in 2020 among the cities included in the “Clean Air” federal project, “Ecology” national project [2].

| City                  | Region           | Level of APa     | Main pollutants in 2020b | Year | AQI | SI>10 | ERR>20 |
|-----------------------|------------------|------------------|--------------------------|------|-----|-------|--------|
| Bratsk                | Irkutsk Oblast   | VH   VH   VH   H  | BP, SP, CS₂, FA, HF      | 2020 |     |       |        |
| Krasnoyarsk          | Krasnoyarsk Krai| VH   VH   H   H  | BP, FA, NH₃, SP, NO₂     | 2020 |     |       |        |
| Novokuznetsk         | Kemerovo Oblast  | VH   VH   VH   H  | BP, HF, SP, NH₃, NO₂     | 2020 |     |       |        |
| Norilsk              | Krasnoyarsk Krai| VH   VH   VH   VH | SO₂, SP, BP , CO, NO₂    | 2020 |     |       |        |
| Chita                | Zabaikalsky Krai | VH   VH   VH   VH | BP, ozone, SP, NO₂, phenol | 2020 |     |       |        |
| Magnitogorsk         | Chelyabinsk Oblast| VH   H   H   E  | BP, FA, SP, NO₂, CO      | 2020 |     |       |        |
| Chelyabinsk          | Chelyabinsk Oblast| H   E   E   E  | FA, HF, NO₂, CO          | 2020 |     |       |        |
| Lipetsk              | Lipetsk Oblast   | E   L   L   L  | NO₂, BP, F, SP, phenol   | 2020 |     |       |        |
| Mednogorsk           | Orenburg Oblast  | E   L   L   L  | lead, SP, SO₂, NO₂, BP   | 2020 |     |       |        |
| Nizhny Tagil         | Sverdlovskaya Oblast| H   L   E   H  | FA, BP, NO₂, NO, SP      | 2020 |     |       |        |
| Omsk                 | Omsk Oblast      | L   L   L   L  | BP , NH₃, NO₂, FA, CO    | 2020 |     |       |        |
| Cherepovets          | Vologda Oblast   | E   L   L   E  | CS₂, NO, FA, NO₂, SP     | 2020 |     |       |        |

a The level of pollution is evaluated by one of the four categories:
(L—“low”, E—“elevated”, H—“high” and “very high” - VH), established by the basic indicators.

b The pollutants with the greatest contribution to the level of air pollution.

BP – benz(a)pyrene; SP – suspended particles; PM₁₀ – particulate matter in the air with a diameter <10 um;
FA – formaldehyde; EB – ethylbenzene; CO – carbon oxide; CS₂ – carbon disulphide; HF – hydrogen fluoride;
H₂S – hydrogen sulphide; NH₃ – ammonia; NO₂ – nitrogen dioxide; NO – nitrogen oxide;
SO₂ – sulfur dioxide; HCl – hydrogen chloride; HM – heavy metals.
3. Results and discussion

Table 2 shows the number of cities and stations in each of the 27 subjects of the Asian part of Russia conducting air pollution monitoring, as well as the total number of cities with the values of the main pollution indicators: AQI>7, Q> MAC (Q – annual average concentration of any substance), SI>10 and ERR> 20.

The Table 2 shows that the level of pollution over the past 5 years is steadily high, although there is a tendency to reduce the number of cases of AQI>7.

The number of cities in Asian Russia where air pollution is monitored is 93, the number of monitoring stations in them is 241. AQI>7 means that the level of air pollution is considered high. The cities participating in the federal project “Clean Air” have achieved success in reducing the level of air pollution (Table 3) [2]. Compared to 2017, in 2020 the level of air pollution in 7 cities has decreased, in 5 cities – has not changed.

Air purity requires financial investments, and the federal budget allocated 31.2 billion roubles for these purposes in the period from 2021 to 2023, and the total amount of extrabudgetary funding is about 500 billion roubles.

The project participants include the Ministry of Natural Resources and Ecology of the Russian Federation, supervisory authorities, industrial enterprises, companies of various forms of ownership, regional governments, the Russian Ecological Society. Industrial enterprises use their own funds to carry out activities aimed at reducing emissions, including the introduction of efficient environmental technologies, installation of gas purification equipment, and improvement of technological processes. Regional authorities are taking measures to improve the environmental situation. First of all, they are engaged in renewal of public transport, conversion of buses to gas fuel, help people living in private houses to switch from wood and coal to gas heating, are engaged in landscaping and beautification of cities [2].

4. Conclusion

The problem of air pollution requires a comprehensive approach and a huge financial investment. The federal project has demonstrated that significant change is possible if efforts at all levels of implementation are properly coordinated.

It is necessary to increase the number of air monitoring stations and expand air monitoring programmes. The latter will allow for a more complete and adequate assessment of the hazardous emissions of individual economic entities, as well as the effectiveness of air protection measures envisaged by the federal “Clean Air” Project in the future [5].

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