Regional aspects of atmospheric air

A A Bayanova
Irkutsk State Agrarian University named after А.А. Yezhevsky, Molodezhnyj village, Irkutsk region, 664038, Russia

E-mail: Bainova.aa@mail.ru

Abstract. Monitoring of atmospheric air in urban and rural areas of the Irkutsk region revealed the presence of pollutants. Air pollution is affected by emissions from the largest industrial enterprises in the aluminum, petrochemical and chemical, woodworking and forest industries of the region; annual forest fires significantly aggravate the situation; small boiler houses, furnace heating contribute. The surveys determined a part of the atmospheric air samples with increased MPC in urban and rural areas. Observations of changes in the specific gravity of air pool samples indicate an increase in the inconsistency of hygiene regulations in Bratsk, Irkutsk and Angarsk. Recommendations on reducing exceeded levels of pollutants are given.

In the Irkutsk region, the qualitative and quantitative state of the air environment is affected by the influx of harmful compounds emitted as a result of the activities of large industrial enterprises of aluminium and ferrous metallurgy, heat power, chemical and petrochemical, forestry, woodworking industries, and production of construction materials [1-3]. A significant contribution to the unsatisfactory position of the region's airspace is made by forest fires. An additional pollution of the air basin is caused by many small boiler houses, apartment houses with stove heating and automobile transport that occur during dry periods, peat fires [4]. Numerous observations have shown the negative impact of air pollution on human health [5–7]. Therefore, monitoring the state of atmospheric air is an important task [8].

The purpose of the research is to identify regional aspects of the state of atmospheric air in the Irkutsk region. Objectives of observations: to analyse the proportion of atmospheric air samples in excess of the maximum permissible concentrations (%) in urban and rural areas, to trace the dynamics of the specific gravity of atmospheric air samples that do not comply with hygienic regulations at monitoring points.

The research method is the implementation of local operational observations of atmospheric air quality.

In the course of the state socio-hygienic monitoring of environmental factors, atmospheric air quality monitoring was carried out in thirty municipalities of the region at thirty-six observation posts.

Monitoring studies of the atmospheric air state in the period from 2015 to 2017 showed an excess of maximum permissible concentrations of pollutants. Non-correlation of hygienic indicators with regulatory standards decreased in 2017. At the same time, a decrease in the share of atmospheric air samples with an excess of MPC of pollutants in 2017 compared to 2016 in urban and rural areas, respectively, by 0.8% and 0.5% (table 1).
Table 1. The percentage of atmospheric air samples exceeding the MPC*(%).

| Area                  | 2015 | 2016 | 2017 |
|-----------------------|------|------|------|
| Rural settlements     | 0.2  | 1.2  | 0.7  |
| Urban settlements     | 0.4  | 5.1  | 4.3  |

*the maximum allowable concentration of pollutants.

In the last investigated year in the air, excesses of the regulations for the content of pollutants in urban areas were recorded mainly in observation posts (7.6%) (table 2). In urban settlements in the area of highways, there was an excess increase from 0.55% in 2015 to 2.2% in 2017. In the zone of industrial enterprises influence, the excess in the period of 2016-2017 decreased from 3.7% to 0.8%.

Table 2. The percentage of atmospheric air samples exceeding the MPC* in rural and urban settlements, %.

| Area                                | 2015 | 2016 | 2017 |
|-------------------------------------|------|------|------|
| Rural settlements                   | 0.5  | 1.2  | 0.7  |
| Urban settlements                   | 2.0  | 7.1  | 7.6  |
| (at fixed monitoring stations)      |      |      |      |
| Urban settlements                   | 0.55 | 1.9  | 2.2  |
| (on highways, in dwellings zones)   |      |      |      |
| Urban settlements                   | 0.2  | 3.7  | 0.8  |
| (in industrial environment affected area) |      |      |      |

In the cities of the region, the degree of air pollution depends on the production activities of large industrial companies, which include aluminum enterprises in the cities of Shelekhov, Bratsk with a capacity of up to one million tons of aluminum per year; ferroalloy enterprises in the cities of Shelekhov and Bratsk; factories of the chemical industry of Angarsk and Sayansk; timber industry complex of Bratsk and Ust’-Ilimsk with a capacity of up to one million marketable pulp per year; heat power organizations. Road transport contributes to air pollution and small and medium-sized industries as well.

Cities of the investigated area differ in the level of air pollution. A dangerous situation is created in the cities of Shelekhov, Angarsk, Bratsk (table 3), which is facilitated by the climatic conditions of the area, which create an obstacle to the industrial emissions dispersion.

Observation of the change in the specific gravity of atmospheric air samples that do not meet hygienic standards has shown a downward trend in the cities of Shelekhov, Ust-Ilimsk, Cheremkhovo, Zima and Ust-Ilimsky district. The increase in maximum permissible concentrations was recorded in the cities of Bratsk, Irkutsk and Angarsk.

Most often, the excess of MPC is recorded among substances prevailing at the aluminum industry, which include fluorine with compounds (in terms of fluorine) of more than 13%, phenol is more common among widespread pollutants and is more than 11%, suspended solids are more than 7%, nitrogen dioxide is about 1.5% and nitric oxide is more than 1.5%.

Due to the very high degree of atmospheric air pollution, the Priority List of Russian Cities in 2017 included the cities of Bratsk, Zima, Usolye-Sibirskoye, Cheremkhovo, Shelekhov. In Bratsk, the excess of carbon disulphide, benzopyrene, nitrogen dioxide, formaldehyde, suspended solids MPC 1.1-5.0, and hydroxybenzene MPC 1.1-> 5.0 is systematically determined. Zima is characterized by an excess of many compounds, namely benzopyrene, nitrogen dioxide, hydrogen chloride, formaldehyde, carbon monoxide. In Usolye-Sibirsk, an excess of many compounds is also recorded, namely, benzopyrene, nitrogen dioxide, hydrogen chloride, formaldehyde, carbon monoxide. In Cheremkhovo, multiple
excesses of benzopyrene, nitrogen dioxide, suspended solids, sulfur dioxide, carbon monoxide are also found. In the city of Shelekhov, excesses of a number of substances were revealed, including benzopyrene, suspended solids MPC 1.1 $> 5.0$, ozone, formaldehyde MPC 1.1 $> 5.0$, hydrogen fluoride MPC 1.1-5.0.

**Table 3.** The dynamics of the atmospheric samples that do not meet the hygienic standards in monitoring points.

| Municipal entities (ME) | % samples exceeding MAC | Exceeding MAC polluting substances (2017) |
|-------------------------|-------------------------|------------------------------------------|
| Bratsk                  | 0.1 0.5 0.5 5.6 7.4    | Hydroxybenzene, fluoride gaseous compounds, suspended substances, methanethiol |
| Irkutsk                 | 1.6 1.8 0.3 0.0 1.5    | Nitrogen dioxide, suspended substances, carbonic oxide |
| Shelekhov               | 5.3 17 20.1 22.6 12.8  | Nitrogen dioxide, formaldehyde, fluoride gaseous compounds, fluorides inorganic poorly soluble, suspended substances, hydroxybenzene, dihydrosulfide, ethylbenzene |
| Ust'-Ilimsk             | 0.5 0.5 0.4 0.2 0.0    | Suspended substances, sulphur dioxide, formaldehyde, dihydrosulfide |
| Ust'-Ilimsk district    | 0.2 0.0 0.0 0.2 0.0    |                         |
| Cheremkhovo             | 1.1 0.5 0.0 0.3 0.0    |                         |
| Zima                    | 1.3 1.4 1.8 1.1 0.0    |                         |
| Angarsk                 | 2.0 2.0 1.0 0.6 1.5    |                         |

Bratsk took the fourth place in the Priority List of Russian Cities in 2017 because of too high levels of air pollution. The unfavourable environment is facilitated by the characteristic climatic aspects of the frequency of days with adverse weather conditions, which makes it difficult to disperse emissions of polluting compounds into the atmosphere.

Government of the Russian Federation Decree No. 183 dated 03/02/2000 established a regulation for the emissions of certain polluting compounds in the region for three industrial enterprises located in the cities of Bratsk and Shelekhov. In the case of the execution of the planned measures to reduce atmospheric air pollution at the production site, the release of some pollutants is temporarily allowed. The emission of fluoride gaseous compounds, benzopyrene in the cities of Bratsk and Shelekhov for JSC RUSAL Bratsk is allowed. In the city of Shelekhov, Silicon CJSC the emission of inorganic dust with a silica content of more than 70%. This forced measure exacerbates the unfavourable state of the atmosphere is temporarily allowed.
According to the results of observations of regional aspects of atmospheric air state, excess of maximum permissible concentration of harmful compounds in urban and rural areas was revealed, an increase in non-compliance with hygienic standards was noted mainly in urban areas, the following measures are recommended to reduce the excess of regulations for the content of pollutants:

• installation of gas and dust cleaning equipment;
• transfer of enterprises to closed production;
• increase in the level of purification of emissions;
• adherence to sanitary protection zone regulations;
• implementation of protective measures in the form of laws and legal documents, restricting polluting activities in the form of fines and emission taxes;
• development of incentive measures in the form of tax benefits, loans for the construction of treatment facilities, and equipment reconstruction.

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