Ecological load on the industrial area of Irkutsk region

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Abstract. Unfavorable ecological situation has arisen in the Irkutsk region. The Irkutsk region ranks third into the amount of pollutants emitted into air from stationary and mobile sources in the Siberian Federal District in 2017. The enterprise activities results in the emission of harmful substances into atmosphere. High concentration of air pollutants is observed in large cities of the Irkutsk region. The work is aimed at the calculation of the ecological load on the main industrial cities of the Irkutsk region for the period from 2008 to 2017. The relevance of the research issue is determined by the increasing intensity of anthropogenic impact and pollution of the urban environment by emissions from motor vehicles and industrial enterprises. We used data on emissions into the air in cities of the Irkutsk region, presented in the State reports as a source of information. In eight industrial cities of the region, the level of air pollution is assessed as high and very high. The cities of Bratsk and Irkutsk have been included over the years in the Priority List of Russian Cities with the highest air pollution index. All of these industrial cities of region have been experiencing a high anthropogenic load, resulted in heavy air pollution.

1. Introduction

The largest enterprises of the electric power industry, aluminum, chemical, coal, mining, timber, wood processing, pulp and paper, engineering, light and food industries are located on the territory of the Irkutsk region. The region ranks first in Siberia with respect to the amount of mercury pollution. The Irkutsk region ranks third among the regions of the Siberian Federal District in 2017 in the amount of emissions from stationary and mobile sources [1]. In the Irkutsk region, there are many sources of pollution [2]. This was related to the fact that there is a powerful industrial zone in the region (about 700 industrial facilities). The quantitative and qualitative composition of the emitted pollutants into the atmosphere, water and soil is determined by as follows: machine-building complexes, enterprises of the chemical, petroleum, aluminum, forestry, woodworking industries and thermal power engineering. Up to 80% of emissions come from stationary sources of industrial enterprises, numbering about 22 thousand in the region [3]. They are the main sources of air pollution. Air pollution by industrial emissions covers large areas of the region. Spatial and temporal variability meteorological potential for air pollutant dispersion has the greatest significance in industrial centers [4]. Meteorological conditions are the main factors that influence the concentrations of pollutants in the atmosphere [5]. Selegei T.S. has developed a methodology for calculating the meteorological potential for the dispersion of impurities in the atmosphere using meteorological characteristics [6]. Most often unfavorable weather conditions are observed in Irkutsk for dispersion of impurities in the atmosphere [7]. Wind rose of climatic factors influences regional pollution on a regional level.
Western and northwestern transfers prevail in the wind rose, which contributes to the pollution of the most developed agricultural lands. Fogs are also very often observed in the region, which also contribute to the accumulation of pollutants in the surface layer. The unfavorable climatic factors also include the Siberian anticyclone, which is observed over the territory of the region in the cold half-year. The windless weather in the anticyclone also contributes to the accumulation of impurities in the atmosphere.

In general, according to the average, the soils of the Irkutsk region are under load with lead, zinc, cobalt and sulfates. According to maximum indicators, almost all cities are polluted with nickel, cadmium, copper, cobalt, and absolutely all the soils of the analyzed cities contain excess of maximum permissible concentrations (MPC) for lead, zinc and sulfates. The role of heavy metals is dual: on the one hand, they are necessary for the flow of physical processes, on the other hand, their increasing concentration is toxic and dangerous to human health. The most dangerous forms of metals for humans and wildlife are mobile, since they have high biological activity. The most powerful flows of heavy metals occur around the ferrous and especially non-ferrous metallurgy, chemical industry and energy enterprises as a result of atmospheric emissions. The effect of emissions extends to tens of kilometers in the atmosphere from the source. Thus, metals in the amount of 10 to 30% of the total emissions extend over a distance of 10 km or more from an industrial enterprise. The assessment of soil contamination by residual quantities of pesticides in crops and in storage areas is conducted annually in the region. The most polluted are the soils of the Irkutsk and Cheremkhovo districts.

2. Models and methods

The area of the Irkutsk region is 774,846 km², which is 4.52% of Russian territory. In its resource and industrial potential, the Irkutsk region takes one of the main places. This is one of the few regions of Russia where there are all kinds of its own fuel and energy resources (more than 8% of all-Russian coal reserves, more than 7% of oil and combustible gas, and 11% of hydrological energy resources). In amount of forest cover (83%) and timber reserves (8.8 billion m³) the region leads among the Russian regions. Fossil resources are of national importance, namely gold, mica, talc, potash and sodium chloride, rare metals and iron ore. Within the region there is a high probability of discovery of industrial diamond deposits. The largest industrial cities of the Irkutsk region are included in the Priority list of the most polluted cities in Russia [8].

Ecological load is a degree of anthropogenic impact on natural complexes, causing changes in ecosystem components, which can lead to a violation of their natural functions [9]. Ecological load $EL$ on the territory of cities was calculated by the formula:

$$EL_i = \frac{\sum Mi}{S}$$

where $Mi$ is emissions from stationary sources (in $10^3$ tons), $S$ is the area of the territory (in km²).

As a baseline, we used data on air emissions in the cities of the Irkutsk region, presented in the State reports “On the state and protection of the environment of the Irkutsk region” for the period of 2008–2017 [10].

3. Results and discussion

Figure 1 shows the dynamics of air emissions from stationary sources in the region. According to data from 2008 to 2017 there is a slight decrease in emissions from stationary sources. The volume of capture and neutralization of the total amount of pollutants from all sources averages 78% over the years. All the largest industrial enterprises are concentrated in Irkutsk, Angarsk, Shelekhov, Cheremkhovo and Bratsk. These cities belong to territories with a pronounced unfavorable ecological situation, and have been experiencing a great ecological load.
We calculated the ecological load for the main industrial cities of the region for the period from 2008 to 2017 (figure 2). In addition to a number of regular systematic observations conducted as part of pollution monitoring, there are methods for calculating the ecological load, both on area of pollution and the environmental load on the population. The presence of pollutants on the territory leads to soil contamination, pollution of water resources and higher morbidity of the population.

Figure 1. Dynamics of emissions from stationary sources in the territory of the Irkutsk region.

Figure 2. Ecological load from stationary sources on main industrial cities of the region.
Also, large complex anthropogenic load causes a decrease in species diversity and loss of biosystem sustainability. The cities of Shelekhov, Angarsk, Bratsk, Irkutsk, and Usolie-Sibirskoe have been experiencing the greatest environmental stress. This is due to location of large industrial facilities here that pollute the atmospheric air with harmful impurities. In the city of Shelekhov, an increase in the ecological load is observed; its maximum value (1,226 $10^3$ tons/km$^2$) was recorded in 2017. The main air pollutants of the city of Shelekhov are IrkAZ-SUAL and power-and-heating plant No. 5 (PHP-5). In Angarsk, the peak ecological load was in 2012 (1.271 $10^3$ tons/km$^2$), and then there was a slight decrease (0.928 $10^3$ tons/km$^2$ in 2017). The main enterprises affecting air pollution in the city of Angarsk are PHP-1, 9, 10, Irkutskenergo (heat and power engineering) and Angarsk Petrochemical Company (APCC). In Bratsk, the ecological load over the studied 10 years varied from 0.470 in 2008 to 0.423 $10^3$ tons/km$^2$ in 2017. The main contribution to air pollution is made by the Bratsk Aluminum Plant (BAP). In Irkutsk, an increase in the ecological load is observed, since 2008 it has increased by 0.183 $10^3$ tons/km$^2$. The largest amount of pollutants enters the atmosphere from the sources of the Irkutsk Aviation Production Association, Novo-Irkutsk PHP, and Baikalenergo. The ecological load on Cheremkhovo, Svirsk and Zima is less than on the cities discussed above, during the study period it varied from 0.028 to 0.056 $10^3$ tons/km$^2$. The main contribution to emissions from stationary sources in Cheremkhovo makes PHP-12, in Zima – Novo-Ziminskaya PHP.

4. Conclusion

The cities of the industrial zone of the Irkutsk region are areas with a pronounced unfavorable environmental situation. This is facilitated by the location of large production in the region, functioning for many decades, as well as chemical, pharmaceutical industry, PHPs, engineering, aviation plant, located in urban areas. An assessment of the environmental impact on the area of cities in the region showed that industrial enterprises with a large anthropogenic load from stationary sources placed considerable stress on the cities. Thus, the distribution of pollutants depends on such factors as the properties of the pollutants (their degree of harmfulness), climatic parameters of the territory and chemical soil characteristics. The local soils are experiencing significant anthropogenic pressures associated primarily with the specifics of the economic activities of enterprises, overcrowding of the industry associated with the industrial development of the region and vehicle emissions. It is necessary to introduce federal and municipal government programs, as well as monitoring and measurements, independent environmental audits are required to achieve the target and planned environmental indicators.

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