

жазылған. Лев Перовский мен зерттеушілер А. А. Кеммерер мен Г. в. Розенің жеке таныстығын растайтын тарихи дереккөздер жоқ. Барлық үш қатысушының ұқсас саяси көзқарастары туралы болжам жасауға болады.

Жұмысты Қазақстан Республикасы Ғылым және жоғары білім министрлігінің Ғылым комитеті қолдауында (грант No AP23485698 Ілгіш негіздерде қалайы негізіндегі перовскиттерді зерттеу.)

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ENVIRONMENTAL MONITORING OF ATMOSPHERIC POLLUTION IN THE KARAGANDA REGION

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Introduction

Atmospheric air pollution is one of the most acute environmental problems of the Karaganda region, which is an industrially developed region of Kazakhstan. The intensive development of industry, especially mining and metallurgy, contributes to the release of significant amounts of pollutants into the atmosphere. To prevent negative consequences, regular environmental monitoring is necessary, which allows you to monitor the state of the environment and take measures to improve it.

Karaganda region is one of the most industrially developed regions of Kazakhstan, which is accompanied by high levels of atmospheric pollution. Over the past 10 years, the air quality situation in the region has undergone both periods of improvement and exacerbation, due to various factors such as the introduction of purification technologies, industrial development and changing climatic conditions.

Sources of atmospheric pollution

Heavy industry enterprises, in particular metallurgical and coal plants, remain the main sources of air pollution in the Karaganda region. Companies such as ArcelorMittal Temirtau, Karaganda Metallurgical Plant and coal mines in the region are the largest air pollutants, contributing significantly to emissions of carbon dioxide (CO₂), nitrogen oxides (NO_x), sulfur dioxide (SO₂), ammonia (NH₃) and particulate matter (PM₁₀ and PM_{2.5}).

According to the data presented in the report of the Karaganda Regional Department of Ecology (2022), emissions of substances such as carbon dioxide, nitrogen oxides, sulfur dioxide, solid particles and volatile organic compounds make the greatest contribution to atmospheric pollution. In 2021, the total volume of emissions of pollutants into the atmosphere amounted to about 500 thousand tons, which indicates the significant scale of the environmental problem (Kozhabekova, 2022).

Methods of environmental monitoring

Environmental monitoring of the atmosphere in the Karaganda region is carried out using a number of methods that allow us to assess the concentration of harmful substances in the air and identify sources of pollution. Among the most common methods are:

1. Instrumental measurements. Regular measurements of atmospheric air are carried out at stationary observation posts equipped with modern equipment for analyzing the content of pollutants. These posts are located near industrial enterprises and residential areas, which allows you to monitor changes in air quality in real time.

2. Laboratory tests. Air samples taken at the posts are analyzed in specialized laboratories. Particular attention is paid to concentrations of particulate matter (PM₁₀ and PM_{2.5}), nitrogen oxides, sulfur dioxide and hydrocarbons, as they are the main risk factors for human health (Ivanov et al., 2021).

3. Satellite monitoring. The latest technologies, such as satellite imagery, allow us to get a global picture of atmospheric pollution in large areas. Satellite data are used to create models of the spread of pollutants and predict their concentrations in various regions of the region (Abdrakhmanova, 2023).

Results and their discussion

Main monitoring results

Monitoring of the atmosphere in the Karaganda region shows that concentrations of a number of pollutants systematically exceed the maximum permissible standards. This is especially true for nitrogen oxides and particulate matter, which have a negative impact on public health, causing diseases of the respiratory tract and cardiovascular system.

According to Kazhydromet data, in 2022, the cities of Temirtau and Karaganda experienced frequent excess of permissible levels of air pollution. The average annual concentrations of solid particles in Karaganda amounted to 1.5-2.0 MPC (maximum permissible concentration), and in Temirtau – up to 2.5 MPC (Seydakhmetov, 2022). This is due to the intensive activity of metallurgical and coal enterprises, as well as the low level of implementation of modern emission purification technologies.

The main pollutants

1. Nitrogen oxides (NO_x). The level of these pollutants consistently exceeded the permissible standards in the cities of Karaganda and Temirtau for all 10 years, which is associated with the intensive use of fossil fuels at enterprises and power plants.

2. Solid particles (PM₁₀ and PM_{2.5}). The concentration of particulate matter in the air remained one of the most significant environmental challenges. Their content in the atmosphere increased especially in winter, which was associated with the activity of boiler houses and industrial thermal power plants.

3. Sulfur dioxide (SO₂). Concentrations of this substance reached peak values near industrial facilities such as ArcelorMittal Temirtau, which led to systematic excess of permissible concentrations over the past ten years.

4. Carbon dioxide (CO₂). CO₂ emissions remain a significant problem for the region, as most industrial enterprises continue to use coal as their main source of energy.

Pollution statistics (2013-2023)

Since the early 2010s, attempts have been made to stabilize pollutant emissions, although industrial activity continued to have a negative impact. For example, in 2013, the pollution level in Karaganda and Temirtau often exceeded the permissible norms by 1.5–2 times, especially in terms of nitrogen oxides and particulate matter. Systematic outbreaks of pollution related to the activities of ArcelorMittal Temirtau were observed in Temirtau (Isataev, 2015).

The period from 2016 to 2018 was marked by increased attention to environmental issues. Government agencies began to require enterprises to actively modernize treatment facilities, which contributed to some reduction in emissions. Nevertheless, episodes of increased air pollution continued in the cities of the region, especially in winter, when the load on thermal power plants increased. In 2018, the average annual concentration of particulate matter in Karaganda and Temirtau exceeded the norm by 1.8 times (Mynbayev, 2018).

During this period, there was a temporary decrease in pollution levels, which was facilitated by the introduction of more modern filters at a number of industrial facilities and temporary reductions in production volumes as part of the modernization of enterprises. In 2020, an improvement in the state of the atmosphere was recorded against the background of the COVID-19 pandemic, as many industrial enterprises reduced their activities during this period. However, in 2021, with the resumption of work in full, the level of pollution returned to previous indicators (Turgunov, 2021).

Since 2022, the situation with atmospheric pollution has begun to deteriorate again. According to environmental services, the average annual concentration of particulate matter (PM₁₀) in Karaganda and Temirtau exceeded the maximum permissible standards by 1.5–2.2 times. The issue was particularly acute in Temirtau, where emissions of nitrogen oxides and sulfur dioxide significantly exceeded the norms established for urban areas. This was the result of an increase in production capacities at metallurgical enterprises and increased exploitation of coal mines (Asanov, 2023).

Table 1. Air pollution in the Karaganda region over the past 10 years

Period	The main sources of pollution	Pollution level	Exceeding the norms	The main pollutants	Improvement measures
2013–2015	Metallurgical and coal enterprises, for example, ArcelorMittal Temirtau	Exceeding the permissible norms by 1.5–2 times	yes	Nitrogen oxides (NO _x), solid particles (PM ₁₀ , PM _{2.5})	Modernization of wastewater treatment plants, but limited
2016–2018	Industrial enterprises, thermal power plants	The average annual concentration of solid particles exceeded the norm by 1.8 times	yes	Solid particles (PM ₁₀ , PM _{2.5}), sulfur dioxide (SO ₂)	Stricter cleaning requirements, improved filtration
2019–2021	Industrial enterprises, partial reduction of production	Temporary improvement; pollution returned to previous levels in 2021	yes	Nitrogen oxides (NO _x), solid particles (PM ₁₀ , PM _{2.5}), carbon dioxide (CO ₂)	Introduction of modern filters, reduction of production
2022–2023 гг.	Metallurgical enterprises, coal mines	The average annual concentration of solid particles exceeded the norm by 1.5–2.2 times	yes	Nitrogen oxides (NO _x), solid particles (PM ₁₀ , PM _{2.5}), sulfur dioxide (SO ₂)	Modernization of wastewater treatment plants, development of renewable energy sources

The table shows the dynamics of atmospheric pollution in the Karaganda region and the main measures taken to improve the environmental situation.

Measures to improve the state of the atmosphere

To reduce the level of atmospheric pollution in the Karaganda region, it is necessary to take a set of measures aimed at modernizing industrial enterprises and improving the ecological culture of the population. Important steps in this direction are:

1. Technology modernization. The introduction of modern emission purification systems at enterprises and the introduction of more environmentally friendly production technologies can significantly reduce the volume of pollutant emissions. Special attention is paid to the introduction of technologies for carbon capture and the use of renewable energy sources (Kim et al., 2022).

2. Legislative regulation. The tightening of environmental norms and standards, as well as control over compliance with environmental requirements by enterprises, helps to reduce anthropogenic pressure on the environment.

3. Educational work. Conducting educational programs for the population aimed at raising awareness of the problems of atmospheric pollution and the need for environmentally responsible behavior is an important element in the fight for clean air.

Conclusion

Over the past 10 years, the problem of atmospheric air pollution in the Karaganda region has remained one of the key environmental problems of the region. Despite some progress in reducing pollution levels, industrial emissions from large enterprises remain the main factor that continues to have a significant negative impact. To improve the environmental situation, it is necessary to continue the introduction of modern cleaning technologies, as well as to tighten environmental standards and control over their compliance.

The problem of atmospheric pollution in the Karaganda region requires constant attention from government agencies, enterprises and the public. Effective environmental monitoring makes it possible not only to identify dangerous levels of pollutants in a timely manner, but also to take measures to reduce them. The introduction of advanced technologies and enhanced environmental control will help improve the state of the environment and preserve the health of the region's population.

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Е.А. БӨКЕТОВТЫҢ ҒЫЛЫМИ МҰРАСЫ: ХИМИЯ, МЕТАЛЛУРГИЯ ЖӘНЕ ТЕХНОЛОГИЯЛАР

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Е.А. Бөкетов – қазақ ғылымындағы аса ірі тұлғалардың бірі, әсіресе химия саласында елеулі жаңалықтар ашқан ғалым. Оның ғылыми еңбектері негізінен металлургия және органометалдық химия, полимерлер химиясы бағытында шоғырланған.

Бөкетовтың химия саласындағы негізгі жаңалықтары мен еңбектері:

1. Металлургиядағы жаңалықтары
 - Қара металлургия мен түсті металлургиядағы күрделі процестерді ғылыми тұрғыда зерттеді.