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# AIR QUALITY MANAGEMENT IN THE DEVELOPMENT OF MINING DEPOSITS

The article provides an overview of modern studies on the assessment of the state and management of the quality of atmospheric air in mining deposits. It is estimated that more than 8,100 ore tailings are formed worldwide with a discharge volume of 10 billion $m^3$. The Global Assessment of Pb-Zn Mineral Resources found that the mining and processing of ore in 67 countries, with an average grade of 0.44% Pb and 1.20% Zn, has given rise to a number of environmental problems, the most acute of which is related to air pollution. However, a large amount of waste from Pb-Zn mines is disposed without proper management in tailings, which are potentially dangerous due to exposure to oxidants and weather conditions, such as the eolian effect. Numerous studies unequivocally indicate that pollution of the surface layer of the atmosphere is the most powerful, constantly acting factor influencing humans, the food chain and the environment. In industrialized countries, the optimal combination of the amount of atmospheric pollution and the degree of protection against it is the air quality management system, in accordance with the principles of Environmental Impact Assessment. The review describes the existing methods and technologies for managing dust and gas pollution of atmospheric air at mining enterprises. It is shown that when assessing atmospheric pollution, it is advisable to use, instead of individual meteorological elements, complex parameters that characterize a specific meteorological situation and conditions.

**Key words:** air pollution, aerosols, tailings, climatic factors, air quality management.

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**Тау-кен кен орындарын игеру кезінде ауаның сапасын басқару**

Мақалада тау-кен кен орындарындағы атмосфералық ауа жағдайын бағалау бойынша заманауи зерттеулерге шолу жасалған. Pb-Zn құрамды минералды ресурстарды жаһандық бағалау көрсеткендей, 67 елде жүзеге асырылатын құрамында орташа мөлшері 0,44% Pb және 1,20% Zn бар кенді өндіру және қайта өңдеу экологиялық мәселелерді, әсіресе атмосфералық ауаның ластануын тудырады. Дегенмен, Pb-Zn кеніштері қалдықтарының көп мөлшері тиісті өңдеусіз қалдық қоймаларында орналастырылғандықтан, олар тотықтырғыштардың әсеріне және ауа-райы жағдайларына, мысалы эолды эффектіге өте сезімталдық танытып, үлкен қауіп төндіреді. Атмосфераның жер деңгейлік қабатының ластануы, зерттеулер көрсеткендей, қоршаған ортаға әсер ететін ең күшті фактор болып табылады. Дамыған елдерде Environmental Impact Assessment қағидаттарына негізделген атмосфералық ауа сапасын басқару жүйесі экологиялық және экономикалық мүдделердің ақылға қонымды үйлесімділігін қамтамасыз етуге мүмкіндік береді. Шолуда тау-кен өндіру кәсіпорындарындағы атмосфералық ауа ластануларын басқарудың жалпы принциптері мен практикалық әдістері сипатталған. Атмосфера ластануын талдау кезінде жергілікті мекеннің нақты метеорологиялық жағдайларын ескеру қажет екендігі көрсетілген.

**Түйін сөздер:** атмосфераның ластануы, аэрозольдар, қалдық қоймалары, метеорологиялық факторлар, атмосфералық ауа сапасын басқару.

 

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**Управление качеством атмосферного воздуха при разработке горнорудных месторождений**

В статье приведен обзор современных исследований оценки состояния атмосферного воздуха горнорудных месторождений. По оценкам, во всем мире образуется более 8100 хвостохранилищ рудных производств с объемом сброса 10 млрд м$^3$. Глобальная оценка минеральных ресурсов Pb-Zn, показала, что осуществляемая в 67 странах добыча и переработка руды при среднем содержании 0,44% Pb и 1,20% Zn, что создает экологические проблемы, в особенности, загрязнение атмосферного воздуха. При этом, большое количество отходов Pb-Zn рудников размещено без надлежащего управления на хвостохранилищах, которые потенциально опасны из-за подверженности воздействию окислителей и погодных условий, например эоловому эффекту. Загрязнение приземного слоя атмосферы, как показывают исследования, является наиболее сильным фактором воздействия на окружающую среду. В развитых странах система управления качеством атмосферного воздуха, основанная на принципах Environmental Impact Assessment, позволяет обеспечить разумное сочетанием экологических и экономических интересов. В обзоре описаны общие принципы и практические методы управления загрязнениями атмосферного воздуха на горнодобывающих предприятиях. Показано, что при анализе загрязнения атмосферы необходимо учитывать конкретные метеорологические условия местности.

**Ключевые слова:** загрязнение атмосферы, аэрозоли, хвостохранилища, метеорологические факторы, управление качеством атмосферного воздуха.

## Introduction

In the modern world, mining is necessary because it improves the quality of life, however, it poses a significant danger to the environment. Thus, lead and zinc are widely used in the construction and automotive industries of the world. However, the global assessment of Pb-Zn mineral resources clearly reflects the environmental challenges facing the lead-zinc (Pb-Zn) ores mining sector. At least 226.1 million tons Pb and 610.3 million tons Zn are shown to be present in 851 individual mineral deposits and waste treatment projects in 67 countries at an average grade of 0.44% Pb and 1.20% Zn, (Gavin,2017:1160). Moreover, only China produces most of the used Pb, Zn in the world. At the same time, a large amount of waste (tailings) of Pb / Zn mines is placed in tailings without proper management, which poses a significant risk to the local ecosystem and residents of mining areas around the world (S.Mohr, 2018:17). Tailings are known to be potentially hazardous due to exposure to oxidants and weather conditions. Thus, according to the mining industry operating data, the amount of tailings generated is estimated at about 0.26-2.5 tons for each ton of Pb/Zn ore processed. It is estimated that there are more than 8100 tailings dumps worldwide with a release volume of 10 billion m$^3$ (Tao Chen, 2022: 120328).

The growing negative impact on the environment has caused environmental problems, one of which is related to air pollution. *Atmospheric air pollution* should be understood as the entry into the atmospheric air or the formation in it of pollutants in concentrations exceeding the hygienic and environmental quality standards of the atmospheric air established by the state. *A pollutant* is a chemical substance or a mixture of substances, including radioactive ones, and microorganisms that enter the atmospheric air, are contained and (or) are formed in it in an amount and (or) concentrations exceeding the established standards, have a negative impact on environment, life, human health (Morozov A. E., 2020: 9).

*The purpose of the review* was to study modern research on the assessment of the state and quality management of mining deposits based on an analysis of the work performed by domestic and foreign authors in recent decades.

Particular emphasis was placed on the state of the atmospheric air in polymetallic mines. The materials were scientific papers published by journals included in the global citation indices Scopus and Web of Science.

## Materials and methods

The presented review is based on analysis, theoretical generalization, assessment of the significance of facts, formulation of logical conclusions and practical recommendations from modern literary sources on the problem of air pollution. The research methodology was:

-collection and comparison of information from available and open sources;

- systematization of approaches and methods of air quality management and forecasting;

--comparative analysis of the formation of technogenic atmospheric air pollutions in the world Pb-Zn mines, in order to substantiate the choice of the most appropriate methods for regulating industrial emissions and protecting the atmosphere;

-a review of recent research in the field of assessing the state and management of atmospheric air quality, the role of climatic factors in assessing the state of the surface layer of atmospheric air in mining production, indicating trends in the development of this knowledge in relation to the climatic conditions of Kazakhstan. It is important to note that at the time of writing this review, there were no analytical studies on the topic under consideration in the literature. The authors, based on their own expertise of scientific works of domestic and foreign researchers, made conclusions and recommendations based on existing methods for monitoring and controlling the air quality of mining deposits.

## Results and discussion

Currently, the problem of air pollution is becoming relevant both due to natural causes and the impact of anthropogenic factors associated with an increase in the concentration of carbon dioxide and other greenhouse gases (GHGs) in the Earth's atmosphere, which affects the environment. The atmosphere, unlike the geosphere, has a number of features, in particular, unlimited capacity, high mobility, variability of its constituent components, which is associated with the peculiarities of the physicochemical processes and transformations occurring in it. The features of these transformations are associated with natural, for example, solar activity, geographical location, climate, seasons and days, and anthropogenic factors (Morozov A. E., 2020: 4).

As is known, when fossil fuels (coal, oil, gas) are burned, most of the sulfur they contain turns into sulfur dioxide. With all types of combustion of various materials in the air, atmospheric nitrogen reacts with atmospheric oxygen and nitrogen oxides are formed. These oxides react with atmospheric oxygen and water to form acids (sulphuric and nitric). Acids, together with rain, can fall to the surface of the earth, affecting the soil and organisms (Morozov A. E., 2020: 4). In addition, acid rain can cause acidification of tailings and further activation of various potentially toxic elements (PTEs) in tailings, and even lead to acid mine drainage (Tao Chen, 2022, Haojie Wang, 2022).

The main driver of climate change, according to experts, is the increase in GHG levels in the atmosphere due to human activities. Caused by the accumulation of GHGs in the atmosphere, ongoing climate change lasts from several decades to centuries and is the cause of environmental changes around the world. In contrast, the effects of air pollution occur close to the Earth's surface within days to weeks, and their spatial scales vary from local to regional. Human activities that release long-lived GHGs into the atmosphere also increase the concentrations of short-lived ozone and particulate matter in the atmosphere. The past eight years are thought to be the warmest on record, fueled by ever-increasing concentrations of GHGs and accumulated heat. The average global temperature in 2022 was about 1.15 (1.02-1.27)°C above pre-industrial (1850-1900) levels. According to all data compiled by the World Meteorological Organization (WMO), 2022 was the eighth consecutive year (2015-2022) in which annual global temperatures were at least 1°C above pre-industrial levels[1].

Currently, the global environmental policy has a clear goal to ensure sustainable development, one of the main goals of which is the conservation, restoration and efficient use of the natural environment components (Abakanov E.N., 2021: 11). Finding ways to resolve the above problems in the framework of achieving carbon neutrality, obligations in the Paris Climate Agreement is an urgent task of implementing the sustainable development goal (SDG13) for each country, including Kazakhstan (Doctrine of achieving carbon neutrality of the Republic of Kazakhstan until 2060, Istomin I.S., 2019, Kerimray A., 2016).

According to World Bank experts, air pollution in Kazakhstan is the cause of 10,000 premature deaths and economic damage of more than $10.5 billion a year. In the ranking of countries to combat climate change, Kazakhstan in 2022 took the last place among 64 countries, as the country with the worst air pollution index (API)2.

In total, more than 2.5 million tons of waste is emitted into the air every year. This figure annually increases by 100 thousand tons on average. By 2030, the amount of emissions may reach 3.6 million tons per year (Annual bulletin for monitoring the state and climate change of Kazakhstan, 2019).

The basis for developing optimal solutions in the field of environmental protection and evaluating their effectiveness, as is known, is reliable information about the state of the environment. Currently, in many developed countries, the atmospheric air quality management system, based on the principles of Environmental Impact Assessment (EIA), allows for a reasonable combination of environmental and economic interests. (GAW Report, 207.2017). Atmospheric air quality is understood as a set of atmospheric properties that determine the degree of physical, chemical and biological factors impact on people, flora and fauna, as well as on materials, structures and the environment as a whole (Savitskaya, T. V.2004).

Air quality and climate are interrelated because the chemicals that affect them are linked, and if changes occur in one, they inevitably lead to changes in the other.

*The purpose of atmospheric air quality management* is to ensure compliance with the norms and requirements that limit the harmful effects of production processes on the environment, ensure the rational use of natural resources, their restoration and reproduction (Tsyplakova E.G., 2012).

Air quality management mechanisms may include:

- development and application of norms and standards for atmospheric air quality;
- control and regulation of pollutant emissions, for example, through licensing and permit procedures for enterprises and industries;
- application of the best available technologies and production processes;
- promotion of the transition to the use of alternative energy sources;
- development and implementation of programs to limit the use of transport based on fossil fuels (Tsyplakova E.G., 2012).

The globally recognized general principles of the EIA are as follows: consideration in the relationship of technical, environmental, social and economic indicators of the projected economic facility; proposal of several options for the implementation of economic activities that ensure the fulfillment of environmental requirements, taking into account regional features of the environment state; taking into account all aspects of the region's socio-ecological development. When carrying out EIA, the stages of mining operations are taken into account:

- primary exploration of deposits of solid minerals;
- feasibility study of the planned production and primary environmental assessment of its impact on the environment;
- direct construction of facilities necessary for the operation of mining production;
- mine operation;
- closure of production and household facilities of the mine, restoration of damaged land, if possible, to its original form (recultivation).

Due to the length of the development cycle of mining enterprises from exploration to production, which is about 20 years, in the near future, mining companies should focus on ensuring the future development of extractive industries, for which, first of all, it is necessary to solve the following main tasks related to the implementation modern technologies. Namely: ensuring the complexity and completeness of the development of the subsoil, which implies the complete elimination of losses of raw materials and minimization of the amount of waste by processing them into secondary resources, as well as the extraction of accompanying valuable components. This will increase the profitability of production and attract additional funds for the organization of environmental protection measures in order to reduce the impact of anthropogenic pressure on the environment.

Harmful substances entering the atmosphere are divided into three groups depending on the type of sources and the scale of emissions. The first one should include suspended solid particles (referred to as aerosols, but more often as dust), sulfur dioxide, carbon and nitrogen oxides, the latter are formed during fuel combustion (Fetisova N.A., 2001). According to (Svinukhov V.G., 1997), 86% of all emissions are accounted for by these compounds.

*Aerosols* are small and light particles with a diameter from thousandths of a micrometer to ten micrometers, capable of being suspended in the atmosphere for a long time (from several days to several years). The greatest amount of aerosols is contained in the lower layers of the atmosphere and especially in the air of large industrial centers. Aerosols are removed from the atmosphere either as a result of being washed out by precipitation (up to 80%), or due to gravitational settling on the underlying surface (up to 20%) (Morozov A.E., 2020: 5). They play a role in climate change, air quality/human health, ozone depletion, and long-range transport and deposition of toxic substances and nutrients. Aerosol formation dynamics, transformation and removal, which determine size distribution and composition, depend not only on clear air processes, but also on interactions with clouds and precipitation. The complexity of aerosol processes in the environment is so great that it leads to large uncertainties in quantitative understanding of their role in many major environmental problems (GAW Report, 207,WMO,2012).

The second group consists of lead, cadmium and mercury, which are the most toxic substances (Fetisova N.A., 2001). Environmental pollution with the metals listed above is of particular concern and therefore they are classified by the UN interagency monitoring group as one of the 16 most dangerous pollutants (Resolution WHA68.8., 2015).

The third group includes specific harmful substances and their compounds (benzapyrene, xylene, ammonia, etc.) contained in emissions from a limited number of industries.

The range of these compounds is large, but in each specific case it depends on the structure of the industrial complex. The degree of air pollution is assessed by comparing the content of substances in it with sanitary and hygienic standards. Many countries have adopted air quality standards (WHO Regional Office for Europe, 2021). The WHO Global Air Quality Guidelines provide recommended limit values for major air pollutants that pose a threat to public health. These recommendations are of high methodological quality and are developed through a transparent and evidence-based decision-making process[4]. In accordance with the Environmental Code, Kazakhstan has developed standards for maximum permissible and temporarily agreed emissions for stationary sources (Maximum Permissible Concentrations of Pollutants in the Atmospheric Air of Populated Areas, 2015, Environmental Code of the Republic of Kazakhstan, 2021, On Approval of Requirements for Reporting Based on the Results of Production environmental control).

In accordance with Article 182 of the Environmental Code of the Republic of Kazakhstan and other regulatory legal and instructive and methodological documents in force in the country, operators of I and II categories objects (including extractive industries) are required to carry out industrial environmental control, therefore, control measurements at the border of the sanitary protection zone should be produced quarterly (Maximum permissible concentrations of pollutants in the atmospheric air of populated areas, 2015, Environmental Code of the Republic of Kazakhstan, 2021, On approval of the Requirements for reporting on the results of industrial environmental control, 2013, On approval of the List of pollutants, emissions of which are subject to environmental regulation, 2021).

As is known, in mining deposits represented by rocky and semi-rocky rocks, the mining technology involves the number of processes use (drilling, blasting, excavation, loading, transportation, crushing), i.e. is not in-line, and the gap between technological links, as us known, generates additional waste and is accompanied by a negative impact on the environment (increased dust and gas emission, seismic impact, pollution of groundwater by explosion products). The natural environment is exposed to the most significant technogenic load in areas of open-pit mining of mineral deposits and waste storage from the extraction and processing of raw materials.

The air in open pits is a mixture of atmospheric air and harmful impurities of man-made or natural origin. Harmful impurities of technogenic origin include carbon and nitrogen oxides, hydrogen sulfide, sulfur dioxide, aldehydes, radon, suspended solid particles (often referred to as dust), soot, fumes and other substances resulting from the implementation of technological processes, the operation of machines and mechanisms or caused by human intervention in the natural environment[5]. The main sources of dust generation are, as a rule, objects of the cyclic-flow technology of waste rock transportation and tailings. In addition, 10 ($PM_{10}$) and 2.5 ($PM_{2.5}$) micron dust, respectively, can be produced by combustion products. Even with well-organized dust suppression in underground mining (dust content in the mine atmosphere does not exceed 1 mg / m$^3$), during reloading, transportation and crushing of ores, as well as when storing off-balance ores, waste rocks and tailings, only one mine enters the air basin average productivity, together with a hydrometallurgical plant, tens of tons of dust per year. As a result, in the areas where mining enterprises are located, and especially in the areas where man-made massifs (dumps) are located, due to massive dust emissions into the environment, an unfavorable environmental situation develops, which tends to further deteriorate due to the increase in production capacities (Filonov A.V., 2016, Nasolovets, N. B., 2009).

Pollution of the atmosphere surface layer, as shown by numerous studies, is a permanent factor influencing the environment (Pushilina Yu.N. 2011, Gorlov V.D., 1990, Sarah Hayes M, 2010, Karpov V. S., 2012, Tao Chen, 2022 ). The results of such scientific works are used in the organization of work to control air pollution, in the implementation of industrial and urban planning activities, which further contributes to the development of measures for the protection of atmospheric air. (Fetisova N.A., 2001). Fundamental provisions on the main methods and technologies for managing dust and gas pollution of atmospheric air at mining enterprises are set out in the fundamental studies of Melnikov N.V., Rzhevsky V.V., Trubetskoy K.N., Arsentiev A.I., Krasnyansky G.Ya., Khronin V.V., Ochirova B.C. and others (Nasolovets, 2009, Rogalev V.A., 1997, Filonov A.V., 2016).

Currently, in many developed countries of the world, meteorological forecasts of atmospheric pollution are provided. Back in 1970, WMO established a network of stations (more than 110) to monitor background atmospheric pollution. The results of observations are sent to the International Center (USA). The WMO program is part of the more general program of the global environmental monitoring system (WMO, 1987).

Climatic studies of air pollution are developing in two directions. The first is related to monitoring the content of pollutants in the atmosphere, which, in turn, includes the generalization of monitoring data to obtain objective information about the levels of air pollution in settlements, as well as the features of the distribution of pollutants, their spatial and temporal variability. (Fetisova N.A., 2001). Then, from complex and long-term changes, general trends and foundations for areas with different physical-geographical and climatic conditions are revealed. The specificity and acuteness of the ecological situation has a pronounced regional character and is largely determined by the characteristics of natural processes. In this regard, when assessing atmospheric pollution, it is advisable to use, instead of individual meteorological elements, complex parameters that characterize a specific meteorological situation and conditions. (Morozov A. E., 2020:13).

*Meteorological elements* is a general name for a number of characteristics of the atmospheric air state and some atmospheric processes. These include characteristics of the atmosphere state and atmospheric processes that are directly observed at meteorological stations: atmospheric pressure, air temperature and humidity, wind (horizontal air movement), cloudiness (in terms of quantity and form), amount and type of precipitation, visibility, fogs, blizzards, etc. This also includes the duration of sunshine, temperature and condition of the soil, the height and condition of the snow cover, etc. (Morozov A. E., 2020: 13).

The second area of research is the study of meteorological factors that determine the conditions for the transfer and dispersion of impurities, including their leaching from the atmosphere.

The transfer and dispersion of impurities entering the atmosphere are carried out according to the laws of turbulent diffusion, and the retention time of impurities in the atmosphere depends on many factors, the dominant value among which belongs to meteorological conditions. In the atmosphere, gravitational settling of large particles, chemical and photochemical reactions between various substances, their transfer over considerable distances and washing out of the atmosphere take place. Under the influence of all these factors, with constant emissions of harmful substances, the level of pollution of the surface air layer can fluctuate over a very wide range[6]. There i an extensive literature devoted to the study of the climatic factors role and the assessment of the atmospheric air surface layer state in the mining industry (Punia A., 2021, Sarah Hayes M., 2009, Kulshrestha A., 2009, Dawson J. L., 1980, Filonov A. V., 2016, Prabhakar G., 2014, Ivanov, A. V., 2015, Filonov A. V. ,2016). It is noted that in areas of active mining and processing of ores, wind-blown dust from unvegetated tailings can be transported over long distances and then deposited in local communities (Punia A., 2021, Sarah Hayes M, 2009). Elevated levels of Pb, Cu, Zn and Cd were found in soils in Australia (Mount Isa, Queensland) near mining and metallurgical enterprises, in watercourses near tailings (Tayloret M.P., 2010), near smelters in desert pastures (Dawson J.L.,1980), urban and rural areas (Agra, India) (Prabhakar G., 2014). In study (Haojie Wang, 2022), precipitation was identified as the most important driving force for the migration of heavy metals in Pb-Zn tailings, which are hazardous wastes generated after ore crushing, magnetic separation, differential flotation and Pb-Zn recovery from production Pb -Zn concentrates. At present, waste is mainly directly dumped into pits and open fields without any effective treatment (Tao et al., 2019), resulting in hazardous elements such as As, Cu, Cd, Hg, Pb, Zn can constantly penetrate into the natural environment, migrate, be transported and thus seriously pollute the nearby soil and water, especially during the rainy season.

Significant influence on the transfer, accumulation and dispersion of harmful impurities in the atmosphere over a certain territory is exerted by local meteorological conditions. This necessitates the study and assessment of the negative consequences of anthropogenic impacts at the regional level. Based on the results of such studies, a significant number of studies devoted to various aspects of the atmospheric air state and the environment have been published. The study of pollutants, their distribution and diffusion are the basis for standardizing the amount of harmful emissions and developing protective measures in the design of industrial enterprises. Studies (Selegey T.S., 1990, 2015, Vizenko O.S. 1993, Rusanova Yu.V. 1992, Novorotsky P.V. 1994) are important for assessing the potential of the scattering power of the atmosphere of Siberia cities and industrial centers. The study (Akhmedova N.M., 2012) found that a negative result of the extensive development of mining is an increase in dust and gas emissions as the area and height of dumps grow (Beresnevich P.V. 1990) and, as a result, the expansion of zones of direct impact on air swimming pool and surrounding area. Calculations show (Gorlov V.D., 1990, Ivanov A.V., 2015) that with an increase in the height of the dump from 20 to 100 m, the total area of its surface decreases by 4.0–4.8 times, and the dusting area increases 2.5–3.0 times.

(Prabhakar G., 2014) studied the spatial and temporal trends in the concentration of airborne solid particles of metals and metalloids in southern Arizona, characterized by a high density of active and abandoned mines, it was found that periods with a high concentration of fine soil coincide with a higher concentrations of metals in the atmosphere, with higher increases in urban areas. The arid climate favors dust emissions from natural and human activities. The review (Punia A.,2021) also shows that climatic factors such as temperature, precipitation and wind significantly affect the distribution of pollutants in arid/semi-arid regions; wind/water and pollute the environment.

An extensive set of studies of the regularities of the distribution of impurities in the atmosphere, mathematical modeling, regulation and forecasting of atmospheric pollution by emissions was formulated in the studies of Berlyand M.E. Genikhovich, Onikul R.I., Bezugloy E.Yu., Anokhina, Ostromogilsky A.Kh. (Laboratory of Modeling and Forecasting of Atmospheric Pollution); Solodkova S.A. (Institute of Applied Geophysics named after Academician E.K. Fedorov) and others (Berlyand M.E., 1990, Bezuglaya E.Yu. 1986, Onikul R.I., 1998, Pushilina Yu.N., 2011, Meshchurova T. A., 2020).

In addition to these processes, the study of the meteorological conditions of the surface layer pollution includes the forecast and analysis of the pollutants spread from various types sources, the regulation of emissions from industrial facilities and vehicles (Fetisova N.A., 2001, Meshchurova T. A., 2020). In a number of works (Nasolovets, N. B. 2009, Pushilina Yu. N., 2011, Ignatenko O. V., 2020), a study was made of the technogenic pollutants formation in mines, the choice of rational methods for protecting the atmosphere and regulating industrial emissions. The choice of the environmental measures set to reduce pollutants and determine the boundaries of the sanitary protection zone, quarries and coal incisions in the study (Nasolovets, N. B.2009) is based on the dusty emissions of pollutants calculation ($Si0_2$, $SO_2$, $CO$,$NO_2$), using the coefficient of the simultaneity of the technological equipment work and the step-by-step construction of isolines by the mathematical modeling method, taking into account the features of the technological factors influence and the natural-climatic conditions of Eastern Transbaikalia. Ranked calculations of the emissions mass of pollutants in the air (Ignatenko O.V., 2020) during explosive work, during the operation of equipment in a career and when dusting dumps, according to which the bulk (90.8 %) is released when the dust is formed in dumps.

The studies (Selegey T.S., 2015) of the meteorological potential of atmospheric pollution for 196 weather stations of Western Siberia from 1986 to 2010, analyzing the meteorological potential of pollution from 1986 to 2010. revealed a change in meteorological conditions for dispersing impurities in the surface layer of the atmosphere almost throughout the region for the worse due to an increase in the repeatability of weak winds 0 – 1 m/s, with a simultaneous decrease in the repeatability of winds ≥ 6 m/s. Two reasons for this phenomenon are put forward: climate change and, possibly, partial overgrowth of weatherplits. The interconnection of the trends of the meteorological potential of atmospheric pollution with the trends of the API is found, confirming the fact of increasing atmospheric air pollution in the cities of the region when meteorological conditions are worsening.

The hypothesis is put forward that a similar phenomenon can occur in other territories that must be taken into account when planning and placing the productive forces of the region. Indeed, this is confirmed by the assessment of pollutants according to the criterion of the complex index of atmospheric pollution of the Perm Territory cities, (Meshcurova T. A., 2020) where the objects of the chemical, metallurgical industry, the production of fuel and energy resources, electric power, transportation objects are located. It was established that the main volume of emissions from stationary sources is on liquid and gaseous substances. The main components are hydrocarbons, then carbon monoxide is formed in the process of burning fuel resources.

Currently, it is necessary to develop technical means of environmental monitoring, the namely, the development of an effective automated system of environmental monitoring of the mining region's atmospheric air, using the accumulated knowledge in the field of environmental protection and geotechnology. Since the existing technical means of control and monitoring for the atmospheric air state do not always meet modern requirements, have a greater measurement error and do not give a sufficient picture to make decisions to manage of atmospheric air quality[7].

In this regard, the adaptation of existing systems to certain conditions of a particular mining region is necessary. For this, it is proposed to take into account the climatic features of the region, the features of the terrain, the territorial distributions of objects of the mining industry, as well as the volumes and composition of the emissions into the atmosphere. The listed circumstances make it relevant the task of forecasting atmospheric air pollution of the mining region (Pushilina Yu. N., 2011,).

In studies (Onikul R.I., 1998, FetisovaT.A., 2001), based on calculations on mathematical models of turbulent diffusion and the transfer of pollutants, the spatio-temporal characteristics of atmospheric air are considered, using meteorological and climatic data and inventory parameters of emissions into atmosphere.

The use of estimated monitoring includes lower costs, which allows you to cover a fairly large number of types of pollution with a sufficiently large details of spatio-temporal calculated concentrations of pollutants (Meroney R.N.,1992, Hesek F.,1997).

Modeling the processes of air pollution removes a number of inaccuracies and solves such problems as forecasting, placing monitoring posts (stationary and mobile), assessing the contribution of a particular industrial facility to general air pollution in real time in order to take managerial measures to normalize emissions. On the example of the Tula region, such a modeling was carried out with the formation of AP dispersion's maps, which made it possible to carry out the technical implementation of the automated system of environmental monitoring of the atmospheric air state (Pushilina Yu. N., 2011,2014).

In the study (Ivanov, A. B, 2013), the idea is expressed that a decrease in aerosol pollution should be carried out by the operational detection of atmospheric air dominant sources. To do this, use data on the allocation and transfer of suspended particles established in real time, depending on climatic and production factors based on modeling the processes of distribution of pollutants in the air from production facilities under various climatic conditions. A mobile complex of automated suppression of the beach zones dust of tailings using an aerosol fogger form is developed. The study (Ivanov, A. B, 2013) proposes a scheme for the relationship of the complex parameters with the intensity of the dust release and transfer, current meteorological data and the recovery mode based on the use of environmentally friendly compositions.

In the research (Danilov A.S., 2019), the assessment and forecast of the atmospheric air state in the zone of exposure to production facilities of mining enterprises is proposed to be carried out by introducing distance monitoring methods using unmanned aerial vehicles equipped with gas analytical and special sampling equipment.

The system of environmental and technical elements of atmospheric air quality controls proposed in the study (Puring S.M., 2004) on the basis of consolidated calculations of atmospheric air and the risk concept is tested by the example of Samara city. In order to control the chemical composition of atmospheric air in industrial cities located in the zone of petrochemical enterprises influence,in the study (Kulakova E.S., 2019), automatic atmospheric air control stations are installed. An analysis of the pollutants concentration in the atmospheric air of Sterlitamak city was obtained, on the basis of which a list of marker substances for enterprises of the city such station was drawn up. Priority sources of pollutants with marker substances during a period of various wind regime are determined. Models of changes in the concentration of marker substances in the air using the factor regression method have been developed. Approaches to the selection of points and monitoring programs for the quality of atmospheric air in the Pure Air project (Russia) are considered in the study (Zaitseva N.V., 2019).

Thus, calculated methods of monitoring and forecasting atmospheric air of industrial areas are put forward to the forefront both at regional and national levels (Onikul R.I., 1998, Meroney R.N., 1992, Hesek F., 1997, PushilinaJ.N.,2011, Ivanov, A. B, 2013, Kulakova E.S., 2019, Zaitseva N.V., 2019). This trend is due to the development and large-scale implementation of computer-informational technologies that help promote methods of mathematical modeling of the processes of dispersion, transfer and transformation of atmospheric air.

In literary sources of recent years, there is information on the results of studies devoted to the problem of pollution and study of the atmospheric air state in Kazakhstan. However, it should be noted that such studies are episodic, non -systemic in nature, since, often, they are performed according to grants. At the same time, it should be noted that in Kazakhstan methods for calculating emissions of heavy metals are practically not used. It is motivated by the fact that all heavy metals are not released on their own, but as part of solid ingredients – dust. Thus, when calculating emissions from thermal power plants, only ash is taken into account, although a number of heavy metals should be calculated. For non-ferrous and ferrous metallurgy enterprises, only total emissions of particulate matter (dust) are calculated, but there are no reliable methods for calculating heavy metal emissions at enterprises in this industry[6]. In the monograph (Drisz N.A., 2013), well -known methods of combating sulfur containing gases in the development of mineral deposits are generalized and characterized. New methods and technologies for suppressing sulfur -containing gases using refrigerants that gas -absorbing compositions have been proved and substantiated in mine conditions. The analysis of the ecological state of Kazakhstan mining regions carried out in the study (Kanatova, J.K., 2017), showed that the greatest concentration of nitrates is observed in Ekybastuz city, copper and arsenic in Zhezkazgan city. The greatest concentrations and excesses in the cadmium are noted in the Aktobe region – 2.2–2.3 MPCs, in the Vest Kazakhstan region – 2.7 MPC, in the Karaganda region – 1.2 MPCs. Completions on the environmental assessment of territories polluted by polyhlordiphenyls (Berkinbaev G.D., 2008), studies of the content of heavy metals in the snow cover solid remnant (Alybaeva R.A., 2008) Ust-Kamenogorsk city, assessments of the of atmospheric air quality dynamics in Ust-Kamenogorsk city for the period 2009-2019 (Kabdykadyrov.A., 2021), a comprehensive study (Yakovleva N.A., 2013) of the former Aktobe chemical plant industrial site, the study of the atmospheric air quality in Almaty (Omarova MN, 2016) made it possible to establish a high level of environmental pollution of Kazakhstan regions with a wide spectrum of technogenic pollutants, including polyhlordiphenyls. So, the assessment of the content of mobile forms Pb, Cu, Zn is made (Yakovleva N.A., 2013). It is shown (Alybaeva R.A., 2008) that the site distribution of the total concentrations of pollutants has a concentric-zone structure: as it moves away from the industrial site of "Kazzink JSC" is reduced by the spectrum of elements and their relative concentrations fall and there is a clear tendency to a decrease in Pb, Zn, Cu, CA, Ag, Sb, As in the snow cover 'solid remnant. Based on the results of the analysis of the dynamics of atmospheric air quality (Kabdykadyrov.A., 2021), it was found that the average monthly concentrations of sulfur dioxide and formaldehyde has increased in the surface layer of the atmosphere, and cases with high pollution of hydrogen sulfide. Studies have shown the need to create GIS pollution maps and systematic environmental monitoring of all Kazakhstan regions without exception.

## Conclusion

The analysis showed that the state of atmospheric air in the area of mining operations, which affects the components of the environment, is determined by two factors:

- climatic features of the territory, which determine the conditions for the dispersion of polluting components;
- ingredient composition, pollutant emissions and characteristics of sources of harmful emissions.

The development and large-scale implementation of computer and information technologies, in matters of atmospheric air quality management, highlights the calculation methods for monitoring and forecasting atmospheric pollution in industrial areas both at the regional and national levels. In the literary sources there are relatively few data devoted to the problem of pollution and the study of the state of the air environment in the territory of ore production in Kazakhstan. In general, they are episodic, non-systemic. At the same time, in order to fulfill the obligations of Kazakhstan in Conventions on Long-range Transboundary Air Pollution[6], the Paris Climate Agreement and the implementation of the doctrine of carbon neutrality until 2060 it is necessary to continue research on a systematic basis to ensure environmental monitoring and management of atmospheric air quality throughout the country and, in particular, in the industrial mining regions of Kazakhstan. Obtaining high-quality information on pollutant emissions is necessary for managing (forecasting) the flow of pollutants into the environment, planning measures to protect the atmospheric air, strategic planning for the development of sectors of the country's economy. The most acceptable for implementation model of atmospheric air quality management is based on the principles of Environmental Impact Assessment, which is widely used in developed countries. This system allows for a reasonable combination of environmental and economic interests.

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