

PAPER • OPEN ACCESS

Man-made risks of coal mining enterprises

To cite this article: S S Timofeeva and M A Murzin 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **229** 012028

View the [article online](#) for updates and enhancements.

You may also like

- [Research on Deleveraging of New Energy Enterprises and Risk-taking of Enterprises](#)
Wang Juan
- [Remediation of TENORM residues: risk communication in practice](#)
C König, C Drögemüller, B Riebe et al.
- [Review of engagement activities to promote awareness of radiation and its associated risk amongst the Japanese public before and after the Fukushima Daiichi Nuclear Power Plant accident](#)
Akihiro Sakoda, Naoki Nomura, Yujiro Kuroda et al.



ECS
The
Electrochemical
Society
Advancing solid state &
electrochemical science & technology

DISCOVER
how sustainability
intersects with
electrochemistry & solid
state science research

Man-made risks of coal mining enterprises

S S Timofeeva, M A Murzin

Irkutsk National Research Technical University, Russia

E-mail timofeeva@istu.edu

Abstract. In this article, we considered a comparative assessment of man-made risks at coal mining enterprises in the Irkutsk region. We carried out an assessment of the man-made risk components: occupational risks, using three different methods, and environmental risks, taking into account the index of air pollution and specific indicators of environmental and economic damage to the environment. We also identified a high-risk enterprise and proposed measures to eliminate the main man-made risks components.

1. Introduction

The active scientific and industrial development, the intensification of production processes and the development of new territories in Russia in their entirety led to an increase in the demand for mineral resources, and this in its turn only confirmed the indispensability and need for the mining sector. But an increase in capacities of mining and primary processing of minerals as well as the development of new, previously explored deposits coupled, in most cases, with the disregard of the rational subsoil use or production environment conditions by the majority of subsoil users, leads to an increase in the probability of negative events, or man-made risks.

Man-made risks are a combination of risks associated with human economic activities. In a broad sense, man-made risks imply all negative impacts from production activities that cause adverse effects both for the environment and for humans themselves, or, in other words, they are a combination of environmental, occupational and emergency risks.

Indeed, it is no secret that almost any human production activity is always associated with damage to the environment in the first place. This is particularly true for the mining industry. Preparation for the development of the field, the implementation of preparatory and mining work - all this causes irreparable damage to the natural environment. The catastrophic nature of such exposure is not least of all connected with the involvement of the environment spheres, be it land resources, water bodies, atmospheric air, or flora and fauna.

Development activities significantly affect atmospheric air pollution in mining regions. Emissions into the atmosphere mainly include the exhaust gases of the internal combustion engines of quarry machinery, aerosols of the extracted raw materials and host rocks. It is deplorable to know that out of the total amount of hazardous substances produced, 2/5 does not undergo any treatment, precipitating over large spaces.

It is widely known that the open-cast mining makes no direct impact on water resources. However, a negative impact does exist. In the process of field development, natural reservoirs are drained, groundwater is polluted by drilling mud, dump formations are eroded by atmospheric precipitation,



followed by pollution of groundwater, deposition of dust and toxic gases on the surface of natural water bodies.

The total impact on the soil surface during the field development occurs as a result of the soil surface disturbance during mining operations, the divestment of land for dump formations, the construction of buildings, structures, utilities and roads. Upon completion of the field development, a land reclamation procedure is of course mandatory, but while the field is being developed, disturbed lands are a source of water pollution as well, which occurs by washing hazardous substances off the soil surface into the surface and ground waters and the atmosphere by dusting dumps and quarry benches.

The vegetation development depends on the weather conditions of the territory, geobotanical zone, topography, soil, water cut, light and other factors. The species diversity and size of animal populations are directly related to the nature of the vegetation in the area under consideration, the food reserve, the position of the watercourses and water bodies, the territory topography and the disturbance factor. As a result of this entire impact on the considered elements of the biosphere, the conditions for the growth of plants and animal habitat significantly deteriorate. The impact on the atmosphere, water resources and lithosphere adversely affects the animal and plant world, causing the oppression and extinction of the natural environment.

But let us not forget that humans themselves are essentially biological organisms. And all the main hazardous production factors initially affect them. Technological processes of mining are accompanied by significant dust emissions, noise and vibration. Mining personnel are exposed to adverse environmental factors that can lead to the development of occupational diseases and pose occupational hazards to workers. Working conditions at mining enterprises are characterized by the combined effect of the production environment factors and can be aggravated by environmental conditions. All these factors may ultimately lead to the development and complication of occupational diseases of workers.

The results of many years of work related to the study of the working conditions of employees at mining enterprises unanimously state the presence of a whole complex of multifactorial negative impacts on personnel, leading further to significant negative consequences for humans. The main factors for the mining industry are the factors of the production environment, such as aerosols of fibrogenic action, gas pollution, production noise, general and local type vibrations, radiation of various nature, unfavorable microclimate, etc. Nearly in all occupations engaged in work directly associated with the technological process, their levels and concentrations do not meet regulatory requirements.

In the hierarchy of occupational morbidity in the mining industry, the leading positions belong to respiratory diseases, vibration white fingers, neurosensory hearing loss, diseases of the nervous system and the musculoskeletal system. It should be noted that in recent years, the percentage component of occupational disease groups has changed: the number of persons with newly found pathologies of a vibrational nature decreased, but the proportion of diseases of a physical nature increased.

All these types of impacts are of a permanent and controlled nature. But in case of emergency events loss and damage caused increase dramatically. Emergency situations are unexpected natural disasters that make significant damage to the environment and cause death of people as well as lead to mass mortality of plants and animals, which greatly increases both environmental and occupational hazards.

All of the above made obvious the need for an assessment of man-made risks. And this is also the main objective of this paper, namely the assessment of man-made risks at mining enterprises.

2. Materials and methods

As it was established earlier, man-made risks include environmental and occupational risks. Each of these risk types has many different methods and ways of assessment. Let us consider the rationale for choosing a methodology for assessing each of the risks in more detail.

Occupational risk is the probability of causing harm to health as a result of exposure to harmful and (or) hazardous production factors when an employee performs his/her duties under an employment

contract or in other cases established by the Labor Code of the Russian Federation and other federal laws. The choice of a methodology for assessing occupational risks was carried out by analyzing a huge range of methods recommended and established at present for assessing occupational risks in the form of GOSTs of the Risk Management series and guideline documents, methods used at enterprises and reviewed in other scientific literature. Our choice was made in favor of the following methods: scoring method; questionnaire method; method of assessing the individual occupational risk (IOR) level.

The choice of methods for calculating occupational risks was made due to the following considerations:

1. The scoring method uses the results of instrumental measurements of the actual production environment parameters and their comparison with hygienic standards. That is, it is an objective assessment of working conditions and, accordingly, risks.
2. The questionnaire method is based on the subjective perception of risk directly by participants in the production process.
3. The assessment of the individual occupational risk level takes into account the age and individual characteristics of the health status of workers.

The application of several different methods makes it possible to calculate occupational risks objectively, which allows for drawing conclusions from the point of comprehensive assessment. The methods we have chosen are fairly simple and informative for use in the occupational risk management system. At the enterprises under consideration, we studied the staff schedule of mining shops and other local regulatory documents, carried out work to identify the sources and consequences of exposure to hazards, measured production environment factors, and identified the most hazardous production factors. The measurements of the production environment were carried out on the equipment of the East-Siberian Shared Use Center "Technosphere Safety". According to the results of the assessment, we carried out the calculation of occupational risks for the main occupations of the enterprises under consideration using three methods.

We carried out a comparative assessment of the environmental risks of mining enterprises using a number of indicators that were based on statistical data, by means of the air pollution index assessment and environmental and economic assessment of damage to the environment.

API is a comprehensive index of atmospheric pollution taking into account several impurities. A comprehensive API is calculated using a special formula that takes into account the average annual concentration of the pollutant, its average daily maximum allowable concentration and a coefficient that depends on the degree of the pollutant harmfulness (1):

$$API = \sum_{j=1}^m \left(\frac{C_j}{MAC_j} \right)^{p_i} \quad (1)$$

where C_i is the actual average annual concentration of the i -substance in the atmospheric air and its MAC_{cci} ; p_i indicator; m is the number of the substances to be detected.

Of the variety of substances entering the atmosphere, we selected chemicals from the same technological processes, namely, drilling and blasting work (nitrogen oxides, sulfur carbon), excavation, transportation, loading and unloading operations in the storages of the recovered mineral (dust emissions, hydrocarbons, including benzo(a)pyrene). These sources of fugitive emissions are spread over large areas.

The assessment of damage from the enterprise's development of fields was carried out by us by means of the environmental and economic assessment of damage to the environment, which we calculated as an economic assessment of the impact on land resources and atmospheric air.

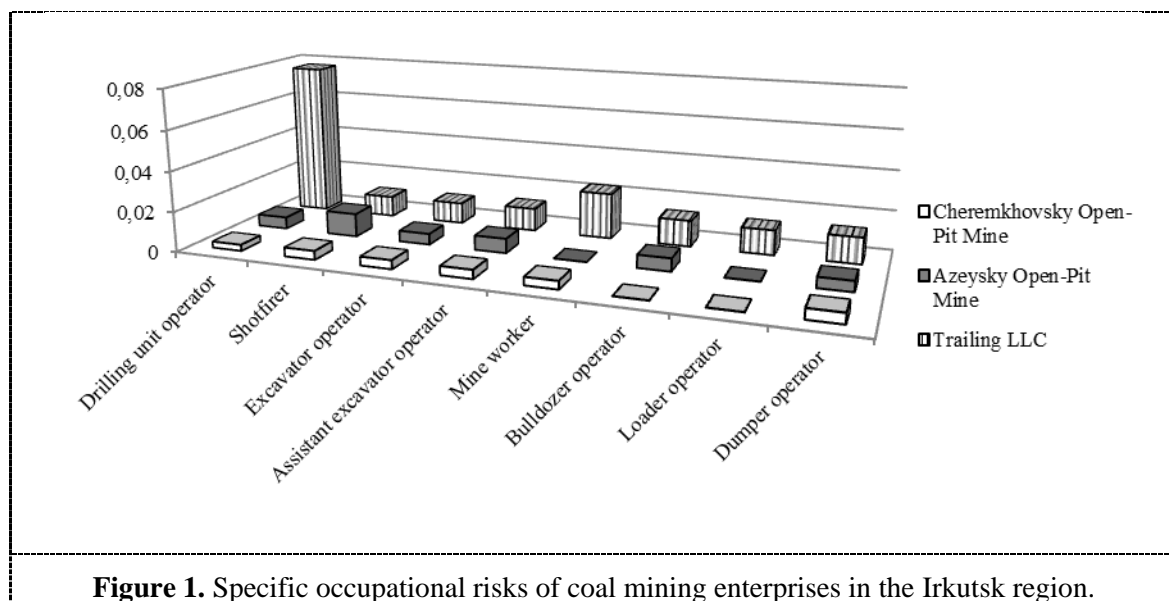
3. The results of the study and their analysis

We chose the coal mining enterprises of the Irkutsk region as the objects of research. The choice of the coal mining enterprises was based on the significance of this natural resource for Russia as a whole, and for the Irkutsk region in particular.

On the territory of the Irkutsk region there are three large coal basins - the Irkutsk, Kansk-Achinsk and Tunguska basins, with total explored reserves of 13.5 billion tons. Mining is mainly carried out within the Irkutsk coal basin comprising four main fields: Cheremkhovo, Azeykoye and Mugunskoye fields, but relatively recently, the development of the Tunguska basin at the Zheronskoye field began. The annual level of coal production in 2017 amounted to 12.2 million tons. Mining operations in the Irkutsk region are carried out by 5 enterprises in 12 facilities. The main production volume is carried out by VostSibUgol LLC, that is 11.4 million tons. We chose the subdivisions and subsidiaries of VostSibUgol LLC, namely the branch Cheremkhovsky Open-Pit Mine, the branch Azeysky Open-Pit Mine and Trailing LLC, as the objects of research.

The branch Cheremkhovsky Open-Pit Mine is a structural division of VostSibUgol LLC. Annual mining of black coal amounts to more than 3 million tons. The branch Azeysky Open-Pit Mine is also a structural division of VostSibUgol LLC. It in its turn mines brown coal with annual production of 2.9 million tons. Trailing LLC is a subsidiary of VostSibUgol LLC and develops the Zheronskoye field at the Vereinsky site, with an annual production capacity of 1.5 million tons.

The assessment of occupational risks was carried out, as previously discussed, using three methods for the main occupations of the enterprises in question. The calculation results were summarized and compiled into a single comprehensive indicator in the form of specific risks equivalent to a thousand tons of coal mined, which are presented in Figure 1. As a result of the assessment, it was found that the highest specific occupational risks are characteristic of Trailing LLC. This enterprise, compared with the others considered, is relatively small and does not provide effective protection of personnel against the negative impact of production factors.

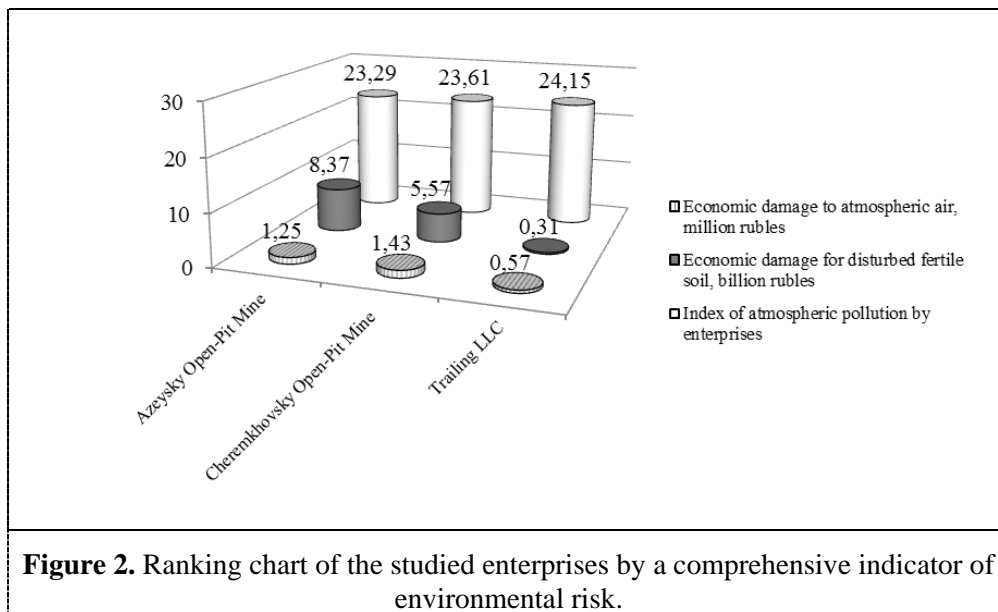


According to the results of the air pollution index assessment, the lead again by a slender margin was taken by Trailing LLC. This is primarily due to the high level of dust in the atmosphere when conducting technological operations.

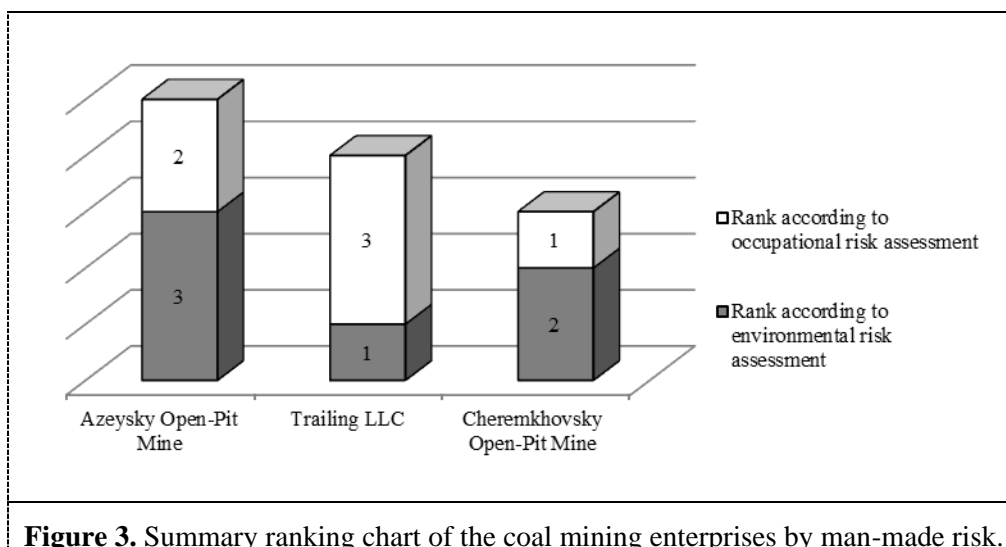
The assessment of environmental damage from air pollution by stationary and mobile sources of emissions was carried out based on specific damage indicators representing monetary estimates of damage from the emission of a unit of the reduced mass of pollutants emitted into the atmospheric air. According to the results of the calculation, it was found that the total annual economic damage to the atmospheric air during the operation of the coal mining enterprises under consideration amounts to 3,265.08 thousand rubles.

When extracting minerals, the soil is disturbed and solid waste is generated. The total environmental and economic damage to land resources from the activities of these enterprises amounts to 14.23 billion rubles.

The results of the environmental risk assessment are presented in Figure 2. Based on the results of the environmental risk assessment, the branch Azeysky Open-Pit Mine was identified as a high-risk enterprise.



Ranks were assigned to the enterprises under consideration based on the combination of occupational and environmental risks. After summarizing the risk assessment results, we found that the branch Azeysky Open-Pit Mine had the most significant man-made risk index (see Figure 3).



4. Discussion

The results of the man-made risk assessment allowed us to identify a significant probability of their occurrence and the magnitude of their impacts. Controlling organizations and management of the enterprise having a high man-made risk should pay attention to the consequences of maintaining such

a negative trend. As a measure to reduce occupational risks, the enterprise needs to address risk management issues in the following areas: technical improvement of mechanical equipment, technological and organizational improvement of the mining process, production modernization and improvement of working conditions.

To reduce environmental risks at the enterprise, it is proposed to carry out work in the following manner: to organize monitoring of the environment state, to assess the environment state and identify its negative changes; to organize the reclamation of land disturbed by mining operations in accordance with the license conditions upon completion of the recovered reserves; to organize the storage of overburden and host rocks in dumps for further effective land reclamation.

The implementation of such measures will reduce the probability and damage from the occurrence of the considered emergency situations at these enterprises.

5. Conclusion

If we talk about the problem of man-made risks in Russia, then it must be said that a comprehensive risk assessment should be carried out only on the basis of regulatory methods. And even despite the fact that the resulting comprehensive risk assessment is attributed to absolute values, their essence is more related to relative meaning, since these risks are identified on the methodological basis. Unfortunately, in Russia very little attention is paid to this issue, and even if it is paid, the issue of the man-made risk assessment is not considered at all. Abroad, more than a thousand different research and theoretical papers are devoted to a comprehensive risk assessment. And even despite the fact that this problem was raised in 1975, in Russia the complete solution to this issue has not yet been found. Implementation of work in the field of risk analysis and assessment continues to evolve. However, without the necessary attention significant results are not likely to be achieved.

References

- [1] Umanets VN, Bugaeva GG, Kogut AV 2014 Methods of environmental risk assessment for environmental safety management in open-pit mining *Mining research and information bulletin (scientific and technical journal)* **8** pp 73–81
- [2] Kolesnikova LA 2017 Analysis of the environment state in regions with mining enterprises *Coal* **4 (1093)** pp 68–69
- [3] Nimetulaeva GS 2016 On methods for assessing occupational and environmental risk in the field of occupational health *Mining research and information bulletin (scientific and technical journal)* **5** 75–93
- [4] Zhang L 2013 Ecological Risk Assessment of Yulin Coal Mining Area: Based on the PETAR Method *Advanced Materials Research* **726-731** pp 1115–1120
- [5] Tworek P, Tchorzewski S, Valouch P 2018 Risk Management in Coal-Mines – Methodical Proposal for Polish and Czech Hard Coal Mining Industry *Acta Montanistica Slovaca* **23** pp 72–80
- [6] Ishtiaq M, Jehan N, Khan S A 2018 Potential harmful elements in coal dust and human health risk assessment near the mining areas in Cherat, Pakistan *Environmental Science and Pollution Research* **25(15)** pp 14666–14673