Environmental problems in the coal mining industry in Russia

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Abstract. The coal mining industry of Russia is characterized. Today, this industry is one of the most polluting types of human activity. The article provides a comprehensive assessment of the coal industry current impact on the environment, namely on the atmospheric air, the lithosphere, natural reservoirs, etc. The authors have analyzed the reasons and consequences of this industry negative impact on nature and man. The main sources of technogenic load on the environment during the coal deposits development are identified. Such sources include rock dumps, mine water, main ventilation fans, degassing installations, etc. The influence of rock dumps on the natural environment is investigated. The negative impact of the discharge of insufficiently treated mine water on the state of not only natural reservoirs, but also all components of the environment is shown. The composition of mine waters has been studied, which is important when choosing the technology for their treatment. Measures and methods to improve the environmental situation in the places of coal deposits development are considered. In particular, it is proposed to purify mine waters for the purpose of their use for technological, household, agricultural and other needs. The harmful and dangerous factors of the methane presence in the coal deposits development are shown. It is proposed to capture methane for further use, which will reduce its entry into the atmospheric air and at the same time make an economic profit. The principles of ensuring environmental safety in the coal mining industry are considered. Methods of reducing the anthropogenic load using the latest technologies are proposed. The conducted research is relevant and important for the further development of the coal mining industry in the framework of conservation and protection of the natural environment.

1. Introduction
The coal mining industry is one of the main areas of the Russian economy. Coal is used in various branches of human activity, for example, as a fuel, in the metallurgical and chemical industries, etc. Environmental pollution, changes in natural landscapes, soil cover violation, and vegetation destruction occur in the process of coal extraction, processing and use. During the underground development of deposits, the earth's surface gradually subsides, as voids are formed due to the excavation of coal.

On the territory of the Russian Federation, about 193 billion tons of reserves of various coal types (anthracite, stone, coking, brown, etc.) have been explored. Every year about 400 million tons of coal are extracted from the earth's interior. The coal deposits are located on the territory of 85 municipalities of Russia. Today, coal is extracted in 16 basins. The Kuznetsk and the Kansk-Achinsk Basins are the largest ones. The Far East and Eastern Siberia coal deposits are not sufficiently utilized yet. Their development will significantly increase coal production in the country. Of course, it is cost-effective. But it is impossible not to say about the reverse side of the coin: the coal industry worsens...
the environmental situation and harms people's health.

2. Materials and methods
The coal mining industry is characterized as a complex socio-economic system of interconnected enterprises and organizations that make up this complex in a certain territory and have the appropriate infrastructure. Such a system needs effective management, aimed at a rational organization in order to generate profit and, at the same time, reduce the negative impact on the natural environment.

Therefore, it is important to conduct research and analysis of environmental problems that arise during coal mining. The results obtained will improve the environmental situation in the regions of the fields.

3. Results and discussion
In the course of scientific and technological development in Russia, coal mining enterprises are located in the locations of the largest chemical and metallurgical complexes, which creates an increased environmental burden. It should also be noted that environmental problems exist not only as a result of the operation of mines, but also when coal enterprises are closed. For example, after the closure of the mine, it is necessary to constantly pump water from underground horizons. Otherwise, flooding will gradually occur, and as a result, waterlogging of territories.

As you know, environmental pollution has an accumulation effect and often does not immediately show adverse effects. They can have an impact on nature and human health in a few decades.

The possible environmental consequences arising from the operation of coal-fired plants are presented in Table 1.

| Environmental component | Possible consequences |
|-------------------------|-----------------------|
| atmospheric air         | contamination with fine particles (dust); methane pollution; when burning coal, emissions containing highly dispersed ash particles, toxic trace elements and other compounds are formed; pollution by spoil-heap burning products; |
| lithosphere             | sub-developed territories (with closed coal mining, there is a gradual subsidence of the earth's surface); underground fires and mine explosions; the landscape changing; violation of the soil cover; vegetation damage; open pit mining; accelerated soil erosion; landslides; formation of large-area landfills |
| natural reservoirs      | accumulation of mine water in underground horizons; pollution of water bodies as a result of the discharge of highly mineralized mine water. |

The technogenic load on the environment during the development of coal deposits is mainly created by rock dumps (waste piles), mine water, main ventilation fans, degassing installations, etc.

Rock dumps have no direct analogues in nature and are specific artificially created structures. They are technological waste extracted from the earth's interior at the same time as coal, and placed on the earth's surface. The amount of rock is approximately 10–20 % of the mass of the extracted coal. Rocks stored in dumps contain high concentrations of toxic chemical elements. Basically, the rock mass is
exported to the cone (ridge) dumps, which belong to the site (dispersed) sources of atmospheric air pollution.

The dumps dusting and the release of pollutants into the atmosphere directly depends on the composition of rocks, their humidity, as well as on meteorological conditions (air temperature, wind speed, etc.). At the same time, the main danger to humans and the natural environment is represented by sulfur compounds contained in rock dust. Under the influence of atmospheric moisture with dust particles, the formation of sulfuric acid occurs, which causes the precipitation of acid rain.

Acid rain acidifies the soil, while it reduces the content of mobile potassium and phosphorus and, as a result, reduces fertility.

In addition, rock dumps disrupt the natural landscape of the earth's surface, creating a specific technogenic landscape and disturbing the geological balance in nature [1].

Rock dumps lead to chemical toxication (salinization) of nearby soils and waters. Chemicals, including radioactive substances, migrate from the rock mass, especially during rain and snowmelt.

It is established that rock dumps directly or indirectly affect all components of the environment. At the same time, the development of negative consequences depends on many factors, namely, the climate of the area, the characteristic conditions of the preparation of the bases, the features of the physical and chemical properties of the dump rocks, the technology of creating dumps, etc. [2].

The construction of the dump is accompanied by the subsidence of the earth's surface directly under the dump and in the nearest territory under the weight of a huge mass of rock [3]. The amount of drawdown in each individual case will be different and depends on the geological conditions, the height of the dump. When dumps are formed in lowlands, the drained water from the dump accumulates over a certain period of time, which is subsequently redistributed into underground horizons and open reservoirs.

Highly mineralized mine water is particularly dangerous for the environment. Their accumulation in the underground horizons violates the hydrogeological regime of the adjacent territories and increases the level of pollution of natural reservoirs.

The chemical composition of mine waters formed during the exploitation of deposits during the opening of aquifers is diverse [4]. The concentration of pollutants in such waters is determined by the initial composition of underground waters, rocks of deposits, etc. The discharge of mine water into natural reservoirs without treatment leads to an increase in their level of contamination.

For different deposits, the composition of mine waters is individual, but after analyzing the data, we can conclude that the concentration of suspended solids, carbonates, sulfates, chlorides, iron, etc. is mainly increased [5].

According to the conducted studies, the content of suspended substances on average is about 232 mg/dm³, which is more than twice the standard. The high concentration of suspended matter is due to the fact that the grooves and water catchments are not always cleaned in a timely manner, and the mine water is practically not cleaned.

In addition, mine waters have increased mineralization. It varies in the range of 2 to 4 g/dm³ for different coal mines, which also exceeds the maximum permissible values. The discharge of hard mine water without prior softening or desalination leads to contamination of natural reservoirs.

To reduce the anthropogenic impact on the environment and ensure the safety of people, it is necessary to conduct comprehensive studies of the characteristics and composition of mine water for a particular field. The analysis of the obtained data will allow you to choose a method and equipment for water treatment [6].

In the process of production and economic activity, coal mines consume water of both drinking and technical quality. The main sources of water consumption in the coal industry are: the use of water for dust suppression, hydro-mechanization of mining operations, wet coal enrichment, household needs (showers, bathrooms, washing of work clothes, wet cleaning of industrial premises, watering of sidewalks and industrial sites), etc. For example, for household needs, water is purchased from the city's water supply network or pumped from natural sources and used after appropriate treatment. For the same purposes, it is possible to use purified mine water, which will reduce financial costs and
reduce environmental pollution [7].

The treated mine water can also be used for irrigation of agricultural crops. It’s quite enough to use settling ponds or other storage tanks that provide purification from suspended substances.

During coal mining, methane is released into the atmosphere along with the ventilation air, thereby polluting the natural environment. Depending on the field, there is from 5 to 40 m$^3$ of methane per ton of coal. For the use of methane, degassing plants are usually used. However, on the example of the mines of the Central district of Donbass, they are not effective due to the low methane content (up to 30%) in the degassed gas-air mixture [5]. Such a mixture cannot be used as a fuel due to its explosive nature, so it is released into the atmospheric air.

Emissions of methane and other substances change the composition and quality of atmospheric air and create conditions for the development of the greenhouse effect. Therefore, solving the problems of capturing methane for further industrial use will reduce its emissions and at the same time achieve economic benefits.

The following measures will ensure the coal mines environmental safety:
- benefits provision and exemption from environmental pollution charges in the case of environmental technologies introduction;
- greening of coal mining technology;
- improving the employees knowledge level in the field of nature protection;
- timely control and prevention of emergency situations;
- mine water treatment using modern technologies;
- coal seams degassing and extraction of methane from ventilation channels with its further use;
- spontaneous combustion exclusion and rock dumps extinguishing;
- carrying out biological reclamation of damaged lands and slopes of non-burning dumps;
- use of all extractable from the earth's interior components;
- monitoring the environmental aftermath of coal mining, etc.

4. Conclusion
Having conducted research on the coal enterprises environmental problems, it can be concluded that today they are relevant and require further study. Knowing the influences and consequences patterns, it is necessary to develop and implement the latest technologies to reduce the negative environmental impact.

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References
[1] Kupriyanov A N, Manakov Yu A, Kupriyanov O A et al 2021 Reconstruction of the soil-plant layer on the dumps surface in Kuzbass Coal 1139(2) 46-52. DOI: 10.18796/0041-5790-2021-2-46-52.
[2] Gastauer M, Silva J R, Caldeira C F junior et al 2017 Mine land rehabilitation: Modern ecological approaches for more sustainable mining Journal of Cleaner Production 172 1409-1422. DOI:10.1016/j.jclepro.2017.10.223
[3] Vorob’ev E A, Sukhar E A, Petrova E L, Fatkulina A V, Solving the issues of preventing rock dumps burning of coal mines Vesti Avtomobilno-dorozhnogo instituta GVUZ «DonNTU» 15(2) 188-195
[4] Arefieva O D, Shapkin N P, Gruschakova N V, Prokuda N A 2016 Mine water: chemical composition and treatment Water Practice and Technology 11(3) 540-546
[5] Gavrishin A I 2018 Formation patterns of the chemical composition of mine waters in Eastern Donbas Doklady Earth Sciences 481(1) 916-917
[6] Gubina N A, Ylesin M A, Karmanovskaya N V 2018 Ways to increase the productivity and quality of mine water treatment *Journal of Environmental Management and Tourism* **9**(3) 423-427. DOI: 10.14505/jemt.v9.3(27).03

[7] Fatkulina A V, Creation of environmentally friendly technologies for mine water purification *Ecology of industrial production* **105**(1) 24-27