The impact of the mining enterprises in Buryatia (Russia) on the environment

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Abstract. At present, there is a huge amount of industrial waste accumulated in Russia, polluting the environment and covering large areas. The greatest impact on the environment comes from open-pit or quarry mining. Mining activities result in huge quantities of rock being brought to the surface and hence produce significant amounts of waste is generated, which has a negative impact on the natural environment. This is also typical for the Republic of Buryatia, where one of the main environmental problems is the formation of waste from both operating and shut-down mining enterprises. In this article we have analysed consequences of mining on natural environment using examples of operating and shut-down mining enterprises in Buryatia. We also gave typical examples of mining enterprises that have the strongest impact on the ecological condition of the territory.

1. Introduction
The problem of industrial waste management is important worldwide: the amount of industrial waste has increased steadily, while the degree of its utilisation remains very low. According to the carried-out estimations, the enterprises of the mining industry cause the most essential damage to the environment, while processing mineral resources and forming 30% of GDP [6]. The mining industry has a direct negative impact on the environment.

Industrial waste dumps and tailing ponds of operating or closed mining enterprises pose a serious environmental hazard. Dusting from the surface of tailing dams leads to atmospheric and soil contamination over vast areas. In areas of high rock permeability, contaminated water from tailing dams easily penetrates into groundwater. Every year, 60 million tonnes of waste are generated in Buryatia, a significant proportion of which comes from mining operations.

2. Models and Methods
We applied the following methods in the study: comparative-geographical, comparative-descriptive, analytical review of the literature on the use of mining waste.

3. Results and Discussion
At present, mining enterprises operating in Buryatia produce gold, zinc, lead, coal, nephrite, fluorite, uranium, cement raw materials, etc., generating huge amounts of overburden, which are practically not utilized (Table 1).
Table 1. Mining enterprises in Buryatia.

| Enterprise                              | Raw material | Mining method | Environmental hazards |
|-----------------------------------------|--------------|---------------|-----------------------|
| Zun-Kholbinskoye deposit                | Ore gold     | Underground   | Medium                |
| Irokinda deposit                        | Ore gold     | Open-cut      | Medium                |
| Okino-Klyuchevskoye deposit             | Brown coal   | Underground   | Medium                |
| Ozernoye deposit                        | Zinc, lead   | Open-cut      | Medium                |
| Kholbodzhinsky open pit                 | Coal         | Open-cut      | High                  |
| Tugnuisky open pit                      | Coal         | Open-cut      | Medium                |
| Dzhidinsky GOK                          | Tungsten, molybdenum | Open-cut | High                  |

Below we consider the current impact of the mining enterprise PAO Buryatzoloto on certain elements of the natural environment. Buryatzoloto is an operating enterprise developing gold deposits. It is among Russia’s largest gold producers and holds a strategic position in Buryatia. The mining company processes around 3 million m³ of rock mass per year at the Zun-Kholbinskoye and Irokinda deposits.

The Zun-Kholbinskoye deposit is located in the eastern part of the Eastern Sayan, in the Okinsky district of Buryatia, at the headwaters of the Urlik and Kitoi rivers. The Zun-Kholbinskoye deposit has been exploited since 1964. Mining activities disturb the soil cover, the hydrological regime in the surrounding area, and pollute the atmosphere [2]. The sources of air pollutants at the mine are the heating boilers of the Samarta and the Zun-Kholba mine sites, the gold processing plant, the diesel power plant with the fuel and lubricants warehouse, the tailings pond, and the areas of mining and operational works.

Nitrogen oxide and dioxide, benzopyrene, sulfuric acid, sulfur dioxide, ore dust, etc. are emitted into the atmosphere. Mining operations have an increased technogenic impact, and they change the natural temperature regime of frozen rocks. In the process of exploitation of tailing dumps at the mine processing plant, the permafrost has degraded and a temporary talik zone has formed [3].

Deterioration of water resources in the territory of the Kholbinsky mine is associated with the impact on them of industrial, administrative and residential complexes of the enterprise, which includes the industrial site of Samarta and the Zun-Kholba mining area with their shift camps [4]. During the development of gold-sulphide deposit, landscapes are polluted with sulphides of heavy metals – lead, copper, zinc. Tailing ponds, overburden rock dumps, mine waters are the sources of technogenic anomalies formation. One of the most negative factors was the contamination with mercury being used for gold extraction. At the Irokinda mine, mature sands in the tailing pond contain gold in high concentrations, ranging from 0.5 to 5.2 grams per tonne.

Ozernaya Mining Company is currently developing the Ozernoye lead-zinc deposit in the Yeravninsky district of Buryatia. It is planned to build a high-capacity mining and processing (6 million tonnes of ore per year) and to develop the deposit with a very complex composition. The projected lifespan of the deposit is approximately 20 years. During this time, the environmental situation in the Yeravninsky district is expected to deteriorate. The mining enterprise will carry out open-cut mining, with inevitable disturbance of landscapes, emission of dust, carbon monoxide, nitrogen oxide and dioxide into the atmosphere. In the mining process waste dumps will be created where oxidized ore will lie on the surface near the open pit, polluting the soil cover and the landscape. The outer dumps will contain toxic and low-toxic waste. Ore dust from dumps, open pits and tailing ponds, which is generated by blasting operations, will be dispersed by the wind and fall out with atmospheric precipitation, including on Yeravninskie Lakes.

OOO Ugolny Razrez Company is developing the Okino-Klyuchevskoe brown coal deposit located 154 km southeast of Gusinozerskaya GRES, which is the main consumer of the surface mine’s products. In 2009-2010, exploration work was carried out and production of brown coal started in 2011 [5]. The company mines brown coal using the open-pit method. On its territory are located: an open pit, an overburden dump, intermediate coal warehouses, the main industrial site, and a shift
camp. An open pit is an area of open-pit mining for the extraction of lignite. Inorganic dust is emitted during this process (and transportation adds dust from the road). The area of the overburden dump is 50 hectares, which is subject to recultivation after mining.

Coal mining is accompanied by destruction of soil cover and natural landscapes, surface subsidence, changes in topography and formation of sinkholes. This disturbs the natural equilibrium associated with the migration of chemical elements, and also destroys established natural biocenoses. The development of the deposit has already disturbed about 400 hectares of land. Weathering processes on the disturbed land have led to the leaching of various chemical elements.

Previously, the large Kholboldzhinsky coal mine produced 3 million tons of brown coal annually to supply the Gusinoozyorskaya GRES, with hundreds of millions of tons of overburden accumulated in waste dumps.

The Kholboldzhinsky surface mine had been developed since 1963, with Gusinoozyorskaya GRES being the main consumer of the mined coal. In 2000, the mine ceased coal production and work began on its liquidation and mitigation of environmental impacts. After the shutdown of the Kholboldzhinsky coal mine, 1,596 hectares of land were left disturbed by mining operations. More than 400 hectares are occupied by overburden dumps (Figure 1).

The Tugnuisky open pit is one of the largest enterprises in Buryatia, which mines coal at the Olon-Shibirskoye and Nikolskoye deposits. The Tugnuisky coal mine consists of the coal mine itself, an enrichment plant and a loading and transportation department. The company produces 13 million tonnes of coal per year; the coal is mined by open-pit method. Open pit coal mining at the Tugnuisk coal mine is accompanied by significant terrain alterations. Open coal mining at this enterprise is accompanied by significant changes in the topography through the formation of dumps, embankments, dams and open pits. In addition, there is air pollution and geochemical changes in landscapes due to the high concentration of chemical elements in the coal and the large mass of extracted raw materials. In total about 30 million m³ of overburden has been accumulated in the dumps of Tugnuisk and Kholboldzhinsky coal mines.

After the long period of Dzhidinsky GOK operation (1934-1998) more than 40 million tons of complex ores waste and technogenic sands (Figure 2) have been accumulated [1]. Enrichment of tungsten concentrate was carried out by flotation, while other useful components were concentrated in the sulphide product, which was being discharged into the tailing ponds in the amount of about 20,000 tons per year. As a result of the Dzhidinsky GOK’s activities, the soil cover has been destroyed and surface and ground waters have been polluted.
4. Conclusion
Thus, the industrial wastes of mining companies in Buryatia, that has been accumulated over decades of operation, needs to be comprehensively recycled. Waste rock dumps can be used for backfilling roads, sites.

In order to reduce the volume of accumulated waste and mitigate its impact on the environment, the following actions should be implemented:

- mining engineering measures (backfilling of open pits with rocks accumulated in technogenic waste dumps);
- additional extraction of useful components from waste dumps and tailing ponds with subsequent recultivation;
- control over compliance with environmental requirements during mining, loading and transportation of raw materials;
- carrying out remediation, i.e. improvement of landscape properties;
- monitoring of natural complexes in the area of deposit development.

In order to increase the efficiency of mining production it is necessary to expand the industrial use of waste (primarily, in the construction industry of Buryatia), with the introduction of modern technologies for its processing.

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