Environmental Pollution Problems in the Mining Regions of Russia

E. Levchenko(✉), I. Spiridonov, and D. Klyucharev

FSBI IMGRE, Moscow, Russia
imgre@imgre.ru

Abstract. The main types of environmental impact during exploration, development and mining of mineral deposits are considered. The indicators of the environmental situation caused by the mining and mineral processing in the mining regions, as well as the environmental consequences of accumulated mining and industrial waste are presented. The results of environmental monitoring of the Russian industrial cities are demonstrated.

Keywords: Environmental safety · Mining · Man-made waste · Heavy metals · Pollution of the ecosystem

1 Introduction

Intensive economic development due to the steady progress in science and technology entails an inevitable increase in the consumption of minerals. In this regard, the increase in mineral production during the last century, a sharp increase in the mining activities contributed to the accumulation of mining waste and man-made pollution of ecosystems. Besides, despite the obvious benefits of mining for the benefit of man, on the other hand, it is also a powerful source of environmental hazards for biota and humans (Aleksandrova and Nikolaeva 2015).

Many chemical elements contained in waste products, in addition to industrial value, cause toxic effects on the ecosystem.

The mining of mineral deposits leads to a change in the basic physicochemical properties of the lithosphere, including its main functions, i.e., geodynamic, geophysical, resource, and geochemical. The study of changes in the ecosystem's parameters during the life period of a mining enterprise is one of the key goals of an ecological-geochemical assessment.

The high level of the environmental impact is typical of the waste produced by ore processing and metallurgical operations, since their storage requires special engineering structures, and the waste contains chemical components harmful to nature and human health. Their mass is inferior to that of stripped overburden and host rocks, but they affect the environment more perniciously (Spiridonov and Levchenko 2018).

The environmental situation has deteriorated significantly due to the fact that at the end of the last century after the collapse of the USSR, many large mining complexes did not cope with economic difficulties and ceased their activities. The tailings of the enterprises, by majority toxic, have remained uncontrolled. Their conservation and

S. Glagolev (Ed.): ICAM 2019, SPEES, pp. 453–456, 2019.
https://doi.org/10.1007/978-3-030-22974-0_111

reclamation have not been carried out timely; hence pollution keeps on growing. In the soils buried under the dumps tangible geochemical transformations occur. The soils buried 20 and more years ago display a strong oxidation over the whole depth of their profile (e.g., pH stays as low as 3.5–4.0), and soil colloids become destroyed. The soil absorbing complex is disturbed, the mobility of organic matter increases, the soil horizons gain ore components, which additionally differentiate due to unequal mobility. These facts testify the mobility of chemical elements in the dumps, and the latter often remain connected to the watercourse systems and can affect the territory of the mining and processing works in the area of air emissions and waste storages.

2 Methods and Approaches

Monitoring of the natural environment should be carried out at all stages of the mining area life, from exploration to mining and further reclamation of disturbed lands and until the site becomes completely stabilized.

The basis of this paper are ecological and geochemical studies, including the identification of areas of environmental pollution by toxic substances, assessment of their extent and composition of their pollution; assessment of potential geochemical endemicity; zoning of the territory according to the pollution level and the degree of environmental danger. identification of pollution sources; identifying areas of potential man-made objects; ecological and geochemical monitoring and forecast of the development of negative processes; development of recommendations for the rehabilitation of areas of poor ecological condition; identification of populations with an increased risk of morbidity. The result of these studies is the compilation of ecological and geochemical maps portraying the ecological status of the territory.

The study of the environmental health is carried out in the following main areas: mapping of the man-made pollution in soil and snow cover; establishing the characteristics of the response of plants to soil pollution; geochemical studies of ground and surface water, and stream sediments; analysis of the chemical composition of atmospheric air, precipitation and aerosols, industrial waste materials as sources of environmental pollution and objects for the extraction of secondary raw materials; relationships of environmental pollution and health indicators of the population living in the pollution hot spots.

3 Results and Discussion

The share of mining industries accounts for 70–80% of the volume of all man-made formations, which have their own characteristics, due to the composition of the feedstock, the technology of extraction, enrichment or processing, and a number of other factors.

As demonstrated by ecological and geochemical studies, the most serious negative effects are related to: the functioning of large industrial hubs (Nizhny Novgorod, Irkutsk-Cheremkhovo, Khabarovsk, Vladivostok, etc.), as well as exploration and

development of mineral deposits in active mining areas (Kirovsk, Mama-Bodaibo, Khapcheranga, Dalnegorsk-Kavalerovsk, Norilsk, and other areas of similar profile).

On the basis of the analysis of the updated database of available technogenic objects, including rare metal deposits, the allocation of 576 technogenic formations on the territory of the Russian Federation is analyzed.

Relevant location maps were compiled, and ranking of technogenic deposits and formations was carried out using the following parameters: areal extent, storage type(s), type(s) of technogenic formations, hazardousness classes, and level of environmental impact. The man-made deposits and formations were ranked by their effect on the elements of the environment.

The analysis of the hottest spots suggests that a series of the factors provokes the deterioration of the ecological situation in the territories.

Of particular concern is the ore processing plant waste, since it requires special engineering structures, and the waste itself contains chemical elements and compounds harmful to nature and human health. Their amounts are inferior relatively to the masses of stripped barren overburden and hosting rocks, but they affect the ecological situation more perniciously. For example, the environmental situation caused by the extraction of mineral raw materials and the disposal of waste on more than 25% of the territory of the Urals economic region is estimated as a crisis. Slightly less than the area of such lands in the south of the Russian Far East, Khanty-Mansi Autonomous Area, Tyumen Region, Krasnoyarsk Territory and other areas of intensive mining and processing of mineral resources.

According to the environment impact degree, the highly hazardous objects list is as follows: apatite concentrates of the Khibiny apatite-nepheline deposits (TR, Sr, F), enrichment tails of the eudialyte lujavrites of the Lovozero GOK (TR, Th), tailings of enrichment of baddeleyite-apatite-magnetite ores of the Kovdor Mining apatite, baddeleyite ZrO_2). Medium-level objects are waste storages accumulated from the apatite concentrate processing in the Khibiny group deposits (phosphogypsum) containing rare earth metals and gypsum (Bykhovskiy et al. 2016; Karnachev et al. 2011).

The toxicity of mining products depends on their physical condition and chemistries. Understanding the mechanisms of the action of chemical elements and compounds on the environment and public health makes it possible to optimize medical consequences and to carry out acceptable mining and processing of mineral raw materials. At the same time, it is necessary to take into account the whole range of sources and objects of impact in order to create a system of medical and environmental safety of the work areas.

The problems of the urbanized environment as a human habitat become similar to those experienced by geologists, representatives of related professions and the population of geological exploration, mining, oil and gas, and metallurgical enterprises.

Three indicators are accepted in Russia as measures of the soil chemical pollution in Russia; these are the maximum acceptable content (MAC), the background content (Z_b) and crustal abundance/clarke (Zc). We analyzed the weighted average bulk content distribution of heavy metals (the hazardousness classes 1 and 2): Pb, Cd, Hg, Zn, Ni, and Cu. By the above mentioned three evaluation criteria, the cities falling into the 1st (highly dangerous) category are Irkutsk, Penza, Saratov, Chelyabinsk, Yekaterinburg,

the 2nd (dangerous) are Perm and St. Petersburg, and the 3rd (moderately dangerous) include Blagoveshchensk and Vologda.

4 Conclusions

The extent of the loss of land, water, forest, recreational and other resources from subsoil use in general and from unused waste in particular places these processes on a par with negative factors that pose a threat to the country's security.

The environmental consequences of accumulated mining and industrial waste are larger than it is declared in various publications concerning the problem under consideration and are of a global scale.

References

Aleksandrova TN, Nikolaeva NV (2015) Ecological-geochemical estimate of the Russian mining and metallurgy waste. Polytech University Publishers, St. Petersburg (in Russian)

Bykhovskiy LZ, Potanin SD, Kotelnikov EI, Anufrieva SI et al (2016) Rare earths and Sc-bearing man-made formations and deposits in Russia. In: Rare earth and Sc minerals in Russia: Mineral commodities, VIMS Economic Geology Series, No. 31, pp 112–120 (in Russian)

Karnachev IP, Zhirov VK et al (2011) Ecological and sanitary estimate of the Khibiny mining area, Murmansk oblast. Vestnik MGU, vol 14, no 3, pp 552–560 (in Russian, with English abstract)

Spiridonov IG, Levchenko EN (2018) Mining waste and ecological safety. Prospect and protection of mineral resources, no 10, pp 15–24 (in Russian, with English abstract)