Influence of mining complexes on agricultural lands of the Ural Region

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Abstract. The article is devoted to the influence of the mining complexes on the condition of the agricultural lands within the agricultural areas while developing mineral deposits in the Ural region. The work shows the distribution of the land resources in constituent territories of the Russian Federation that form the Ural region, in addition, agricultural areas are identified. The Ural mining region is defined as a place of deposits of solid minerals, the work shows its relationship with the agricultural areas of the constituent territories of the Russian Federation. The influence of the mining complex on quantitative and qualitative characteristics of the agricultural lands is determined, generalized sizes of the areas used for the premises of the mining complex are given. Geoecological assessment of the soil is performed. This soil is under intense technogenic burden due to the waste storage facilities - slag dumps of a metallurgical plant. Recommendations for agricultural land protection in the area of influence from the mining complex are given.

1. Introduction
The Russian Federation Presidential Decree of 31 December 2015 No. 683 "About Russian National Security Doctrine" provides that the food security governance is performed through, among other things, increasing soil fertility, preventing depletion and reducing the area of agricultural land and cropland.

In the "Basic Principles of State Policy in the Sphere of Environmental Sustainability of the Russian Federation for the Period till 2030" approved by the Presidential Executive Order of 30 April 2012 it is stated that almost in all constituent territories of the Russian Federation there is a tendency to the soils and lands damage. Processes that lead to the loss of crop-producing power of agricultural lands and their withdrawal from economic turnover are developing intensively. In turn, use of agricultural lands for the purposes of mineral deposits development is possible only as a last resort and with their transfer to another intended purpose that is why such withdrawal is usually irrevocable.

2. Reference and methodology
In the paper methods of environmental monitoring, graphic modeling and a systematic approach are used. The work is based on a large amount of bibliographic sources, geochemical survey and monitoring research data.
3. Results and discussion

Extraction of mineral resources and primary processing is accompanied with disruption of natural landscapes. During mineral deposits (hereinafter MD) development about 150K ha of land is damaged all over the world every year, and the share of this land occupied in agricultural production accounts for about 40%. One of the most intensively affecting the environment and, in particular, the agricultural lands, is the Ural region, which includes eleven constituent territories of the Russian Federation: the republics of Bashkortostan, Komi and Udmurt, as well as Perm Krai, Kurgan, Orenburg, Sverdlovsk, Tyumen and Chelyabinsk regions, Khanty-Mansi – Yugra and Yamalo-Nenets Autonomous districts, united by their geographical area – the Urals – and the occurrence of the mineral deposits. The overall area of the Ural region is 270421,7K ha. Over a period of more than 300 years of development of mining business from the 18th to the 20th century, 1,673 mining enterprises were opened, operated and ceased to exist on the territory of the mining industry in the Urals, including 1002 mines, 566 metal mines and mine sites, 105 open pits. At present more than 40 mines, 48 metal mines and mine sites, 100 open-pit mines are active, among them there are about 40 big enterprises and a lot of medium and small open-pit mines, not considering mining enterprises for developing wide-spread MD, including building materials and facing stones, their number is about two hundred [1]. During this period according to approximate calculations more than 8,5 billion tons of technogenic-mineral wastes are accumulated. Apart from that it is planned to develop further mineral resources base of the Ural region while providing the industry with mineral resources for the next 150-200 years.

In this case it is quite relevant to consider the impact of the mining on the most valuable lands which are priority for use in the national economy, namely, agricultural ones.

The composition of the land resources of the Ural region is shown in figure 1; the figure shows that the area of the agricultural land in the constituent territories of the Russian Federation of the region is increasing from the North to the South, making up to 1,1% in KhMAD-Ugra, and in Orenburg region is up to 88,4% of the total area of the constituent territory of the Russian Federation. In turn, figure 2 shows the territory of the Ural mining region (UMR) that unites the mining territories (hereinafter – MT) with the development of MD. From the joint analysis of both figures it is clear that MT coincide with the territories of the constituent territories of the RF, where significant areas are occupied by the agricultural land. More detailed information is provided in the table 1, which shows the constituent territories of the RF of the Ural region with the area of agricultural land of more than 20%, and the number of the mining enterprises (liquidated or existing) on their territory. For further analysis the constituent territories of the RF were chosen with the biggest number of the mining enterprises and a significant area of agricultural land.

![Figure 1 Composition of the land resources as per the constituent territories of the RF in the Ural region, total area of the agricultural lands of the Ural region is 76207,9K ha (28,2% of the Ural region area).](image-url)
Figure 2. Ural mining region (development of solid mineral deposits), total area of the mining territories - 29655.1K ha (11% of the Ural region area).

Conditions for grain growing are more favorable in the southern part of the region, i.e. warm-temperate and warm zones of forest steppes and steppes (Republic of Bashkortostan, Kurgan, Orenburg and Chelyabinsk regions), the northern and central parts (Udmurt Republic, Perm Krai, Sverdlovsk and Tyumen regions) are used for animal agriculture and cultivation of potatoes, vegetables, flax, barley and oat.

The impact of the mining complex (hereinafter MC) on agricultural land (farm fields, hayfields, pastures, perennial plantings, etc.) should be considered in the following directions:

- withdrawal of land to develop MD, i.e. extraction of mineral resources, primary processing and location of auxiliary structures;
- changes in the natural conditions of the adjacent lands due to the negative impact from the objects of the active MC on the environment;
- further changes of the land conditions on MT after development of the MD and liquidation of the MC due to the residual impact of the remaining objects of the mining enterprise.

Table 1. Characteristics of the study area.

| Constituent territory of the RF | Agricultural land, thousand ha | Number of mining enterprises |
|---------------------------------|--------------------------------|------------------------------|
|                                 | Total area (%) | Agricultural used area (%) | inactive (liquidated) | active |
| R. of Bashkortostan | 7279.4 | 50.9 | 6624.7 | 91.0 | 59 | 10 |
| Udmurt R. | 1862.1 | 44.3 | 1693.7 | 76.4 | - | - |
| Perm Krai | 4301.7 | 26.8 | 2409.7 | 56.0 | 78 | 3 |
| Kurgan reg. | 4529.6 | 63.3 | 4032.2 | 89.0 | - | 1 |
| Orenburg reg. | 10937.3 | 88.4 | 10473.0 | 95.8 | 21 | 10 |
| Sverdlovsk reg. | 4082.6 | 21.0 | 1999.3 | 49 | 900 | 39 |
| Tyumen reg. | 4565.1 | 28.5 | 2921.0 | 64 | - | - |
| Chelyabinsk reg. | 5173.5 | 58.4 | 4706.7 | 90.1 | 754 | 41 |

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Area of the withdrawn land is different and depends on the method of the MPI development. The largest areas are formed by the open-pit method, they consist of land plots formed for open-pits, dumps for placing uncovering and enclosing rocks, industrial site and transport and engineering communications. The occupied territories depend on the depth of the ore distribution in the mineral resources, very often their area amounts up to hundreds and thousands of hectares. If a mining enterprise is combined with a processing facility, the corresponding territories are occupied by the technological objects of the washing plants and their waste storage facilities. Figure 2 shows the size of some active MC area situated on the territories of agricultural lands.

| Mining complex                                           | Area, ha          |                      |                      | Total  |
|----------------------------------------------------------|-------------------|----------------------|----------------------|--------|
|                                                          | open pit(s)       | dump(s)              | Industrial zone with tailing facilities |        |
| R. of Bashkortostan                                      |                   |                      |                      |        |
| Uchalinskii MPP (Mining and Processing Plant)            | 252.9             | 334.5                | 457.7                | 1042.1 |
| Sibaiskii MPP (Mining and Processing Plant)              | 182.6             | 711.7                | 399.2                | 1292.5 |
| Orenburg region                                          |                   |                      |                      |        |
| Gaiskii MPP (Mining and Processing Plant)                | 309.4             | 717.0                | 718.4                | 1744.8 |
| Kiembayevskii MPP (Mining and Processing Plant)          | 252.1             | 568.2                | 539.4                | 1360.0 |

With the underground mining method of MD the land plots occupied by a mine allotment, as a rule are not withdrawn, but those territories are limited in economic activity, mainly in construction. The exception is mineral extraction by technological development (underground leaching, gas-contacting, melting of a mineral element in the ore body), when a land plot within the mine allotment is formed to place technological equipment. A land plot is usually formed to place a mine site with location of vertical constructions for excavation (shaft), OAB, dumps for placing overburden and engineering communications, its area is 3-10 ha. In the course of mining operations, if the laying of robbed-out stope ores is not used, disturbances of the earth’s surface in the form of subsidence, cracks, sinkholes, etc. appear on the territory of the mining allotment.

Change in the conditions of the agricultural land depends on the level and kind of negative impact of the objects of active MC. Impact of an MC is formed as a result of emissions or draining of harmful substances from the MC sources, or as a result of dust migration or washing-off small particles from the surface of the rock dumps and/or waste storage of the processing production. Such transported substances may be harmful and non-harmful [2], harmful substances are divided into toxic, carcinogenic and radioactive.
In this study toxic substances are considered to be heavy metals [3], which being a part of different compounds can penetrate into the soil and accumulate in plants, then pass into the human and domestic animal food. Changes in the content of heavy metals in plants depending on their concentration in soil in the "soil – plant" system are considered in [4].

When an MC impacts agricultural lands, coal deposits should be separated in a separate group. Although, during restructuring in the 90s of the last century almost all coal-mining Ural enterprises were liquidated, the facilities that remained still have a negative impact on the environment. In the process of technogenic rotting (mechanical and chemical) of surrounding rocks and coal in the dumps and open-pit sides with an increase of specific surface of chippings and decrease of their permeability primary geochemical processes occur: oxidation, dissolution, desalinizing, etc. As a result of oxidation, self-ignition of surrounding rocks and coals in the dumps and open-pit sides occurs. During combustion sulfur dioxide, nitrogen oxides, carbon monoxide, hydrogen sulfide, etc. are generated with an admixture of solid suspensions (soot, coke, etc.). As an example one can name deposits of the Chelyabinsk coal basin, in particular, Korkinskoye coal deposit. The maximum level of contamination is 500 m. Shaft waters formed by the discharge from flooded shafts and dump run-offs (surface and underground waters) are corrosive with a high mineralisation level and concentration higher than LOC of magnesium, iron, aluminium, cadmium, manganese, calcium, etc. [5].

We will consider substances carcinogenic if they cause soil degradation and vegetation suppression. These mainly include certain types of fine (pathological) dust. The spread of fine limestone dust outside the open-pits and washing plants lead to soil degradation, precisely to the increase of pH level, neutralization of carbon and nitric acid, increased content of calcium in the soil, the formation of airtight crusts on the surface, i.e., to soil contamination with limestone dust. Such dust spreads over a distance of 300 m or more [6].

Asbestos dust (finely-dispersed) covers soil and plants with hardly soluble crust, during this process physiological processes of plants are violated dramatically, palisade surface is decreasing, and in summer hot days it leads to the termination of photosynthesis. Penetrating into the soil dust that has up to 43% of magnesium oxide and some amount of calcium and manganese, increases the crop productivity, especially if there is lack of phosphorus [7,8].

After developing the deposit and liquidation of an MC a part of mining facilities remains on the MT. Thus, in the areas of open mining works there are open-pits remained, most of them filled with water, as well as rock dumps (table 3), ruins of building and construction of an industrial site and dirt piles of rocks in the area of underground mining works, and not suspended storage facilities for processing waste.

**Table 3.** Summary on the size of the areas occupied by objects remained after the liquidation of the MC.

| Constituent territory of the RF | Number of flood bypass conduits | Area of flood bypass conduits, ha | Dump area, ha |
|--------------------------------|---------------------------------|----------------------------------|--------------|
| R. of Bashkortostan            | 11                              | 1290                             | 1060         |
| Perm krai                      | 10                              | 170                              | 400          |
| Orenburg reg.                  | 18                              | 310                              | 570          |
| Sverdlovsk reg.                | 60                              | 3580                             | 7760         |
| Chelyabinsk reg.               | 51                              | 2770                             | 7660         |
| Total                          | 150                             | 8120                             | 17600        |

All of this is a source of negative impact on the environment. Thus, for example, 35 kg of dust is carried away from 1 ha of the dump surface; this dust extends for 1-2 or more kilometers from the dump perimeter, dust loss from the tailings dump reaches up to 20 thousand tons in adverse weather
conditions. Spontaneous ignition and burning of dumps can last for decades. In areas of self-flooding of underground mine works, when they are liquidated, self-spills from them are often found, and water removal of underground water from under the dumps and waste ponds is possible. Underground water outlets lead to the saturation of the downstream territories, and sometimes flooding of the earth surface over significant distances [9-16].

So, we carried out a geoecological assessment of the soil state [17,18], under the influence of blast furnace and open-hearth slag dumps, which are on the balance sheet of the Nizhniy Tagil metallurgical enterprise in the city of Nizhny Tagil, Sverdlovsk region [19].

The analysis of figure 3 shows that the soil has a "spotty" contamination. However, most of the territory is occupied by an area with a hazardous pollution category. On the eastern side of the open-hearth dump there is an area with an extremely hazardous pollution category.

![Figure 3: Total indicator of soil pollution.](image)

Territories remained after development of gold-bearing placers in the Middle and South Ural are of a specific character. River valleys developed manually or by dragging method are areas with dredging tailings and dumps with a modified riverbed, as well as a series of successive water bodies along the riverbed, sometimes up to 900 m wide. After developing the river valleys and adjacent territories with a hydraulic excavation method the earth surface remains free from the soil covering and is characterised by developed cavitation (cavities), sometimes with remaining rock outcrops. All this leads to the destruction of flood meadows and disruption of natural hydrological system.

4. Conclusion
Almost all remaining mining territories are left for autoregeneration, partially by overgrowing with forest or tree-shrub vegetation.

In addition, in practice, there are cases of illegal use of agricultural lands for the development of DUM without a license for the mineral resources use.

As the measures of agricultural lands protection, the following points are proposed [20]:

- to improve the quality and efficiency of methods of state land supervision over the intended use of land;
- to improve the quality and efficiency of methods of state land supervision over the environmental planning of the active MC;
- to identify the past accumulated environmental damage in the places of economic activity of the MC, with its comprehensive assessment and subsequent rehabilitation of such territories.

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