The tailing dumps’ reclamation influence evaluation on atmospheric air at the mining enterprise

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Abstract. Mining tailing dumps contain many toxic substances and elements. After the end of their operation, restoration is necessary in order to eliminate the harmful effects on the environment. Reclamation is designed to reduce the adverse effect on the surrounding air of the surrounding areas. In this paper, we consider the effect on atmospheric air during the reclamation period of the Tyrnyauz tungsten-molybdenum mining and processing plant. An assessment of air pollution at the border of the sanitary protection zone (SPZ) and the nearby village.

Introduction
Tyrnyauz tungsten-molybdenum mining and processing plant (TTMP) is a mining enterprise for the extraction and concentration of tungsten-molybdenum ores in the Kabardino-Balkarian Republic. Located in the highlands of the North Caucasus (absolute height up to 3600 m). The field was discovered in 1934 by the geologists V. A. Flerova and B. V. Orlov [1]. It contains almost 37% of proven reserves in the Russian Federation. The Tyrnyauz tungsten-molybdenum mining and processing plant included mines of open and underground work, an enrichment factory, and a geological exploration expedition. During the Tyrnyauzskoye field development, its waste was disposed of in a tailing dump located on the banks of the Gizhgit and Baksan rivers in the Elbrus region of the KBR at an altitude of 1210-1234 m above the sea level. After the plant stopped operating in 2001, ore washing products ceased to flow into the tailing dumps pond, which resulted in the lake’s shallowing and, as a result, an increase in the dry beach of the lake, at the bottom of which there are very dusty elements (TTMP waste), which are blown by winds to very adjacent pasture lands and to the Bylym village. In [2], it was shown that the pollutants concentration in the area of the Bylym village exceeds the MPC by 1.3549 times. To further prevent the beach erosion, it was decided to rehabilitate this beach (Figure 1). The project is aimed at solving a part of the problem of environmental pollution by waste from the Tyrnyauz tungsten-molybdenum mining and processing plant and preventing accidental destruction of the dam of the sump (lake) during floods.
According to the data obtained in [3,4], industrial waste disposal is a complex technogenic deposit of metallic and nonmetallic raw materials. The waste contains more than 100 million m$^3$ industrial ore redistribution waste and there are significant reserves of rare and other elements that are not only economically useful, but also the toxic elements. The studies conducted in [5] showed that the samples taken at the tailing dump site contain chromium, vanadium, cobalt, nickel, copper, zinc, rubidium, strontium, zirconium, barium, lead, arsenic, molybdenum, and tungsten. The average values of the chemical elements’ content in solid waste of the TTMP tailing dumps are shown in Table 1.

**Table 1.** The average content of chemical elements (g / t) in solid waste from the TTMP tailing dumps.

| Element | Cr | V | Co | Ni | Cu | Zn | Rb | Sr | Zr | Ba | Pb | As | Mo | W |
|---------|----|---|----|----|----|----|----|----|----|----|----|----|----|----|
| The average | 65 | 55 | 11 | 28 | 37 | 241 | 51 | 191 | 86 | 153 | 22 | 73 | 111 | 375 |

The contents of useful (W, Mo, Zn, Pb - are of economic value in their extraction), and environmentally harmful (W, Mo, As, Zn, Pb, S, etc.) elements significantly exceed the MPC, which indicates a likely negative environmental load adjacent to the tailing dumps area and the pollution possibility by the toxicant elements of pastures and farmland in the nearby large village Bylym. The dry beach reclamation is designed to reduce the adverse effect on the surrounding air of the surrounding areas.
During the reclamation of the dry tailing dump beach, the main sources of air pollution are: vehicles for road works, material transfer, a diesel installation, and the tailing dump itself. To assess the negative impact on the environment during reclamation, the air pollution sources’ analysis has been carried out.

**Research results and discussion**

Dust emissions from the tailing dump are composed of many substances. In this regard, the harmfulness of multicomponent dust was estimated by calculating the evaluation criterion. Low-hazard dust components due to their low toxicity or low content are normalized as inorganic dust with a normalized content of silicon dioxide. Separate accounting is necessary for manganese compounds [6].

To determine the negative impact degree on the environment, an inventory of the pollutant emissions’ sources into the air has been carried out. According to the inventory data, 10 pollutants are formed as a result of reclamation: manganese and its compounds, nitrogen dioxide, nitrogen oxide, carbon, sulfur dioxide, carbon oxide, gaseous fluorides, xylene, benzapyrene, formaldehyde, kerosene, inorganic dust 20-70% SiO2, inorganic dust no more than 20% SiO2, which belong to 1 - 4 hazard classes for the environment. The list of pollutants emitted into the atmosphere is given in Table 2. For all substances, the values of maximum permissible concentrations are given as follows: MPC m/s - maximum single concentration, MPC a/d average daily concentration and ASEL - approximately safe exposure level [7.8].

**Table 2. List of pollutants emitted into the atmosphere during reclamation**

| Code | Substance Name | criterion used | Criterion value, [mg/m³] | Hazard Class | Substance release [g/s] | Substance release [t/year] |
|------|----------------|----------------|--------------------------|--------------|------------------------|--------------------------|
| 1    | Manganese and its compounds (in terms of manganese (IV) oxide) | MPC [m/s] | 0.01000 | 2 | 0.0252836 | 0.002515 |
| 0301 | Nitrogen dioxide (Nitrogen (IV) oxide) | MPC [m/s] | 0.20000 | 3 | 0.1828009 | 0.412739 |
| 0304 | Nitrogen (II) oxide (Nitric oxide) | MPC [m/s] | 0.40000 | 3 | 0.0296988 | 0.067070 |
| 0328 | Carbon (Soot) | MPC [m/s] | 0.15000 | 3 | 0.0140895 | 0.006615 |
| 0330 | Sulfur dioxide (sulfur dioxide) | MPC [m/s] | 0.50000 | 3 | 0.0369634 | 0.115295 |
| 0337 | Carbon oxide | MPC [m/s] | 5.00000 | 4 | 0.2392377 | 0.722465 |
| 1325 | Formaldehyde | MPC [m/s] | 0.05000 | 2 | 0.0002956 | 0.001167 |
| 2732 | Kerosene | ASEL | 1.20000 | | 0.1232411 | 0.470664 |
| 2908 | Inorganic dust 20[%]-70[%] SiO2 | MPC [m/s] | 0.15000 | 3 | 8.1560000 | 0.811200 |
| 2909 | Inorganic dust: 20[%] SiO2 | MPC [m/s] | 0.30000 | 3 | 0.0734822 | 1.595710 |
| Total substances: | | | | | 8.8810928 | 4.205441 |
Atmospheric air in urban and rural settlements should not have a harmful effect on humans [9].

When the tailing dump is reclaimed, the substances of the second hazard class - 0.0036825 t / year, the third hazard class - 3.008629 t / year, the fourth hazard class - 0.722465 t / year, without the hazard class - 0.470664 t / year. As it can be seen from Figure 2, inorganic dust emissions: 20% SiO2 account for 38% of the total emissions.

To assess the pollutant emissions’ negative impact degree on atmospheric air, the dispersion was calculated using the Unified Program “Ecologist 4.5”. The program makes it possible to determine the maximum concentrations values of pollutants in the surface layer of the atmosphere, identify the sources that make the greatest contribution to environmental pollution, determine the enterprise emissions’ influence zone on the atmosphere surface layer pollution.

The coefficient depending on the atmosphere stratification is 200. The relief coefficient of the area is 1.2. The settlement points were taken at the sanitary protection zone (SPZ) border and at the border of the residential zone. The criterion of safety and harmlessness to humans of atmospheric air, including maximum permissible concentrations (MPC) are established by the sanitary rules [9].

**Table 3. The pollutants’ concentration**

| Substance code | Substance Name                          | Concentrations in shares of MPC at SPZ | Concentrations in shares of MPC residential area |
|---------------|----------------------------------------|----------------------------------------|--------------------------------------------------|
| 1             | Manganese and its compounds            | 0.72                                   | 0.12                                             |
| 0143          | Nitrogen dioxide                       | 0.67                                   | 0.45                                             |
| 0301          | Nitric oxide                           | 0.13                                   | 0.11                                             |
| 0304          | Carbon black                           | 0.03                                   | 0.004                                            |
| 0328          | Sulfur dioxide                         | 0.02                                   | 0.003                                            |
| 0330          | Inorganic dust 20%-70% SiO2            | 0.067                                 | 0.3%                                             |
| 2             | Nitrogen oxide                         | 0.007                                 | 0%                                               |
| 0301          | Carbon                                | 0.115                                 | 0.3%                                             |
| 0304          | Kerosene                               | 0.413                                 | 10%                                              |
| 3             | Formaldehyde                           | 0.471                                 | 11%                                              |
| 4             | Inorganic dust 20% SiO2                | 0.811                                 | 19%                                              |

**Figure 2.** Gross emissions (t / year) of pollutants into the air.
As it can be seen from Table 3 and Figure 3, the pollutants’ concentration in all substances, except for inorganic dust 20% SiO2, does not exceed the MPC.

Summary
Dust air pollution occurs during the performance of many works, especially with the development and movement of soil and stone materials. Much attention should be paid to the proper work organization.
It is recommended to use preventive and protective measures to reduce the dust content during the performance of work, namely: watering the access roads of the site and the work site with water.

The concentration of pollutants for all substances during the reclamation course, except for inorganic dust 20% SiO2, does not exceed the MPC.

To prevent wind erosion of the considered dry beach, it is planned to reclaim it by layer-by-layer rolling with a gravel-sand mixture with a layer of geo-textile. At the end of reclamation, the beach area is reinforced with anti-erosion type geo-mats filled with a vegetative layer and grass sowing [10].

Reclamation of the dry tailing dump beach is aimed at reducing dust emissions, which contain heavy metals present in tailing dumps waste, and will also improve the environmental conditions of plant growth and animal habitats in the area.

References

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