Ecological monitoring of soils under conditions of technogenic effects

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Abstract. The article considers the results of environmental monitoring of technogenically polluted soils. In particular, the sanitary and hygienic state, the content of organic pollutants, the microbiological and parasitological state of the soils were studied. As a result of the studies, it was found that the content of heavy metals does not exceed the MPC, the content of benz-α-pyrene and petroleum products also does not exceed the permissible limits, pathogens and parasites were not detected. And in terms of the number of bacteria of the Escherichia coli group, the soils belong to the group of dangerous soils. Recommendations for the restoration and recultivation of soils are given.

1. Introduction
Every year, the negative impact on the environment, in particular the soil, from enterprises engaged in the development and extraction of minerals increases. In this regard, the biosphere is polluted by various pollutants, and the need for material resources also increases from year to year [1-4].

As a result of the development of mineral deposits, there is an accumulation of high-risk industrial waste. Storage of these wastes has a negative impact on the environment, worsens the ecological situation, leads to disruption of bio-and agro-landscapes, as well as to a decrease in the species diversity of flora and fauna [5-11].

Therefore, at the design stage and the initial stages of field development, it is necessary to conduct preliminary ecological monitoring.

2. Materials and methods
The land plot allocated for monitoring was located on agricultural land alienated for the industrial site of JSC Lebedinsky MPC (mineral processing complex).

Ecological monitoring was carried out according to the following indicators using generally accepted methods:
1. sanitary and hygienic condition (heavy metal content and pH);
2. content of organic pollutants (content of benz-α-pyrene and petroleum products);
3. microbiological status (index of E. coli group bacteria, enterococcal index, pathogenic microflora);
4. parasitological state (helminth eggs, cysts of pathogenic protozoa).
3. Results and Discussion
Preliminary soil inspection showed that the research area contains mainly anthropogenic-modified soils – typical medium-sized carbonate agrochernozem, a complex of technozems, technochernozems, sealed soils.

The state of the soil cover on the research area for the construction of the 35/6 kV power transmission line and the lifting and main conveyor is shown in Figure 1.

![Photo of the soil cover](image)

Figure 1. Photo of the soil cover

Typical mid-power carbonate agrochernozems make up 68.6% of the prospective area allocated for the construction of the transport scheme of the mining and transport complex using cyclic flow technology. The complex of technozems, technochernozems, and sealed soils is 22.0% and 9.4%, respectively.

Thus, the construction will be carried out on the territory with a wide spread of deeply transformed soils that have lost the main typical features, soil-like bodies and man-made surface formations.

The soil profiles of agrochernozem, the most widespread on the territory of the survey site, are shown in Figure 2.

![Soil profile of typical low-power low-humus agrochernozem](image)

Figure 2. Soil profile of typical low-power low-humus agrochernozem
The background soils of the research area are chernozems. According to the Set of Rules "Engineering and Environmental Research" (SR 11-102-97), the corresponding background values and MPC/APC (HS 2.1.7.2511-09) were selected.

The results of studies of typical chernozem in terms of sanitary and hygienic indicators (heavy metal content and pH) from a sampling depth of 0-0.2 m are presented in Table 1.

Table 1. Sanitary and hygienic research of typical chernozem (sampling depth of 0-0.2 m)

| No. of test | Zn  | Cd  | Pb  | Cu  | Hg  | Ni  | As  | pH  |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|
| 1           | 1.0 | 0.1 | 0.5 | 1.0 | 0.01| 0.5 | 0.1 | 6.1 |
| 2           | 1.6 | 0.1 | 0.5 | 1.0 | 0.01| 0.5 | 0.1 | 6.2 |
| 3           | 1.0 | 0.1 | 0.5 | 1.5 | 0.01| 0.5 | 0.1 | 6.0 |
| 4           | 2.1 | 0.1 | 0.5 | 1.4 | 0.01| 0.5 | 0.1 | 6.3 |
| 5           | 1.0 | 0.1 | 0.5 | 1.9 | 0.01| 0.5 | 0.1 | 6.3 |
| 6           | 2.2 | 0.1 | 0.5 | 1.1 | 0.01| 0.5 | 0.1 | 6.1 |
| 7           | 1.0 | 0.1 | 0.5 | 1.2 | 0.01| 0.5 | 0.1 | 5.9 |
| 8           | 1.0 | 0.1 | 0.5 | 1.0 | 0.01| 0.5 | 0.1 | 6.1 |
| 9           | 2.6 | 0.1 | 0.5 | 1.8 | 0.01| 0.5 | 0.1 | 6.3 |
| 10          | 2.0 | 0.1 | 0.5 | 1.4 | 0.01| 0.5 | 0.1 | 6.1 |
| 11          | 1.0 | 0.1 | 0.5 | 1.6 | 0.01| 0.5 | 0.1 | 6.3 |
| 12          | 1.0 | 0.1 | 0.5 | 1.0 | 0.01| 0.5 | 0.1 | 6.1 |
| 13          | 1.0 | 0.1 | 0.5 | 1.0 | 0.01| 0.5 | 0.1 | 6.0 |
| 14          | 2.1 | 0.1 | 0.5 | 1.0 | 0.01| 0.5 | 0.1 | 6.3 |
| 15          | 2.6 | 0.1 | 0.5 | 1.1 | 0.01| 0.5 | 0.1 | 6.2 |
| 16          | 1.0 | 0.1 | 0.5 | 1.0 | 0.01| 0.5 | 0.1 | 6.1 |
| MPC         | 23.0| 2.0 | 6.0 | 3.0 | 2.10| 2.0 | 4.0 | -   |

As a result of the conducted studies, it was found that the studied typical chernozems belong to slightly acidic soils (pH = 5.3-6.2). When analyzing the content of mobile forms of heavy metals, it was found that it does not exceed the hygienic standards for all indicators. The content of cadmium, lead, mercury, nickel, and arsenic was unchanged in all the samples studied and was 0.1, 0.5, 0.01, 0.5, and 0.1 mg/kg, respectively. Some changes in the content were noted in the determination of zinc (in the range of 1.0-2.6 mg / kg) and copper (1.0-1.9 mg/kg).

Table 2 shows the results of laboratory tests of the soil for the content of organic pollutants-benz-α-pyrene and petroleum products-from a sampling depth of 0-0.2 m.

Benz-α-pyrene is a compound belonging to polycyclic aromatic hydrocarbons, belongs to the first class of danger, has carcinogenic properties. The main technogenic sources of benz-α-pyrene entering the environment are objects that emit the products of hydrocarbon combustion, in particular, heat and power plants, and transport. Petroleum products are a toxic substance of hazard class III. The main sources of oil products entering the soil in the conditions of the construction sites under consideration are vehicle emissions, as well as hydrocarbons entering the soil with rain and meltwater runoff.

In typical chernozem, the excess of hygienic standards for the content of organic pollutants was not found in all the samples studied. To fully characterize the sanitary and epidemiological state of the territory, the level of biological contamination of the soil was determined by microbiological and parasitological indicators in accordance with SanPin 2.1.7.1287-03.

Table 3 shows the results of laboratory studies of soil samples for sanitary-microbiological and parasitological indicators from a sampling depth of 0-0.2 m.
Table 2. Content of organic pollutants (sampling depth of 0-0.2 m)

| No. of test | Benz-α-pyrene, mg / kg | Petroleum products, mg / kg |
|-------------|------------------------|-----------------------------|
| 1           | 0.005                  | 0.005                       |
| 2           | 0.005                  | 0.005                       |
| 3           | 0.005                  | 0.005                       |
| 4           | 0.005                  | 0.005                       |
| 5           | 0.005                  | 0.005                       |
| 6           | 0.005                  | 0.005                       |
| 7           | 0.005                  | 0.005                       |
| 8           | 0.005                  | 0.005                       |
| 9           | 0.005                  | 0.005                       |
| 10          | 0.005                  | 0.005                       |
| 11          | 0.005                  | 0.005                       |
| 12          | 0.005                  | 0.005                       |
| 13          | 0.005                  | 0.005                       |
| 14          | 0.005                  | 0.005                       |
| 15          | 0.005                  | 0.005                       |
| 16          | 0.005                  | 0.005                       |
| MPC         | 0.020                  | -                           |

Table 3. Microbiological and parasitological research of typical chernozem (sampling depth of 0-0.2 m)

| No. of test | Microbiological research | Parasitological research |
|-------------|--------------------------|--------------------------|
|             | Index of E. Coli group bacteria | Pathogenic microflora | helminth eggs | cysts of pathogenic protozoa |
|             | Enterococcal index        |                         |              |                              |
| 1           | 100                      | < 1,0                    | -            | -                            |
| 2           | 100                      | < 1,0                    | -            | -                            |
| 3           | 1000                     | < 1,0                    | -            | -                            |
| 4           | 100                      | < 1,0                    | -            | -                            |
| 5           | 1000                     | < 1,0                    | -            | -                            |
| 6           | 100                      | < 1,0                    | -            | -                            |
| 7           | 100                      | < 1,0                    | -            | -                            |
| 8           | 1000                     | < 1,0                    | -            | -                            |
| 9           | 1000                     | < 1,0                    | -            | -                            |
| 10          | 100                      | < 1,0                    | -            | -                            |
| 11          | 1000                     | < 1,0                    | -            | -                            |
| 12          | 100                      | < 1,0                    | -            | -                            |
| 13          | 100                      | < 1,0                    | -            | -                            |
| 14          | 1000                     | < 1,0                    | -            | -                            |
| 15          | 1000                     | < 1,0                    | -            | -                            |
| 16          | 100                      | < 1,0                    | -            | -                            |
As a result of parasitological research of typical chernozem, it was revealed that pathogenic microflora, helminth eggs and cysts of pathogenic protozoa were not found in typical chernozem.

When analyzing the content of bacteria of the Escherichia coli group, it was found that the studied soils belong to the category of dangerous (Index of E. Coli group bacteria = 100-1000), and in terms of the content of enterococci – to the category of clean.

Conclusion
According to the results of the conducted research, it can be concluded that the territory of the survey site allocated for the construction of the transport scheme of the mining and transport complex using cyclic flow technology is characterized by the dominance of anthropogenic-altered soils due to their agricultural and industrial use, which, however, does not exclude the development of a project for removing the fertile layer.

In this connection, after the completion of the construction of the lifting-main conveyors, the power line, the raw materials warehouse, it is necessary to distribute the remaining soil over the recultivated area in a uniform layer. The soil from the site for the construction of a buffer ore warehouse should be sent to a temporary dump with subsequent use for filling trenches, creating a flat surface after compaction of the soil.

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